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DISCOVERY

A MONTHLY POPULAR JOURNAL OF KNOWLEDGE

EDITED BY EDWARD LIVEING, B.A.

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THE DAYLIGHT MICRO-PROJECTOR
WITH ITS INVENTOR, M. DUSSAUD

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JOHN MURRAY, 50A ALBEMARLE STREET, LONDON, W.1.

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DISCOVERY. A Monthly Popular Journal of Knowledge.

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Editorial Notes

ON the recommendation of the Managing Committee, Mr. Murray has appointed to the vacant editorship of DISCOVERY Mr. Edward Liveing, B.A., the author of *Attack* (a description of his experience as an infantry officer in the Battle of the Somme) and well known for his contributions to fiction and poetry in the current periodicals of the day. The Committee hope with confidence that, with the continued co-operation of Dr. Russell as Scientific Adviser, the new appointment will mark a new stage in the prosperity and popularity of DISCOVERY.

* * * * *

At the present moment in the intellectual world everybody is working very hard, and, if appearances at close range are not deceptive, working to good purpose. People who are feeling depressed after the Great War may possibly be doing so because they are meditating upon the wrong things, for it is not difficult to suggest topics the consideration of which will imbue the thinker with optimism and hope. The war has had a bracing effect in general upon the intellectual world. The period 1914–1919 has been like the long and somnolent vacation which precedes the October-to-Christmas term at schools and universities—a time when work is pleasant, and energy and enthusiasm are displayed to the full.

* * * * *

This fact is reflected not only in the large and important contribution which both science and the humane studies are now making to learning, but in the deepening interest which the general public are taking in knowledge of all kinds. Take the present interest in Einstein as an example. Ninety-nine people out of a hundred do not know what Einstein is getting at, but most of them realise one thing, namely, that Einstein has wakened everybody up. He has amazed the physicists and astonished the philosophers. There is not "any money" to be made out of his scientific work, but he has shown us again what science has always been showing to those who will look—that it is really a wonderful world we are living in, and that it is going to appear to us more and more wonderful as the years roll on.

* * * * *

There is one great difference between to-day and, say, thirty years ago: we are more fully conscious that we are on the eve of big discoveries now than men were then. It is said that in the early nineties students of physics thought they had progressed so far with discoveries in that subject that there seemed little or nothing further for the future to do. Of course everything could be developed, constants might be more accurately determined, instruments made more sensitive. But in the main so-and-so's hypotheses were universally applicable, and so-and-so's equations could be adapted to suit all emergencies. It was very nice that things had approached so wonderfully near to finality, that, so to speak, the universe was "taped."

* * * * *

And then a few years later (I am speaking of physics only), Röntgen discovered the X-rays, Becquerel discovered radioactivity, and Madame Curie radium. Rutherford showed that nature was continually doing herself what the alchemists for centuries had failed to do—to bring about transmutation of elements. Marconi telegraphed without wires. The men who humbly

and reverently thought they had the universe " taped " had to confess their mistake when the feeble opposition which some of them put up to the new theories had been completely demolished by experimental facts. One thing is very certain now, and that is, that in thirty years the people living then will look upon us as blind as bats for failing to discover the host of obvious things which to them will be commonplace.

* * * * *

Progress and development in science have been very much in my mind through reading recently several books on the history of that subject. In particular one book, published by the Cambridge Press, has interested me very much, *The Scientific Papers of the Hon. Henry Cavendish, F.R.S.*[1] This is really a magnificent work. Every lover of science must be grateful to the editors of these two volumes for their labour of love, and to the publishers for their courage and enterprise in publishing this complete edition of the scientific writings of Cavendish.

* * * * *

These two volumes are the final garnering of the work of one of the greatest of discoverers. They contain the whole of Cavendish's previously published work and all the important work that has hitherto remained unpublished. The first volume appeared in a different form in 1879. It was then edited by Professor Clerk Maxwell. In 1874 Cavendish's papers preserved by his kinsman, the Duke of Devonshire—a very remarkable and even mysterious record of progress in electrical as well as in chemical science—were put into Clerk Maxwell's hands, and the editing of the MSS. was his chief continuous literary occupation until his death five years later. The result was *The Electrical Researches*, of which it has been said " there is no instance in the history of science in which the unpublished records left by an investigator have been arranged and elucidated with such minute fidelity." The first volume is a new edition of this one. It has been carefully revised and annotated by Sir Joseph Larmor. It contains as an appendix Dr. Thomas Young's life of Cavendish, printed originally in the *Encyclopædia Britannica*, and as frontispiece a reproduction of the only portrait of Cavendish extant, a water-colour sketch preserved in the British Museum.

* * * * *

The second volume is quite new. It deals with the chemical and dynamical work. Sir Edward Thorpe, who edits it, has gone carefully through the unpublished papers dealing with researches in chemistry, and has welded the mass into a most interesting whole. He contributes a most valuable introduction. On special points he has had the assistance of four of his colleagues in the Royal Society.

* * * * *

Henry Cavendish (1731–1810) was a remarkable man. There was nothing Byronic about him. He differed so greatly from the conventional eighteenth-century type that a superficial observer might almost consider him eccentric. He did not quite manage to sell all that he had and give it to science. He gave himself, which was a great deal, and the rest that he had accumulated at the bank—accumulated there for other people. For a man whose grandfathers were dukes he lived a very simple and unostentatious life, being no more lavish in his expenditure than the man whom Mr. Punch conceives to be the canny Scot. Yet when he died he left a million and a half. He was undoubtedly one of the originals of a once popular conception of a scientist, the eccentric who can explain the universe, but is not quite sure of the change of a shilling. He had shy, conservative, and unconventional habits. He had a hatred of women, of talking, of any town except London, of any meat except mutton. His voice on the rare occasions when he used it was squeaky, and his manner embarrassed. A contemporary writer says of him that " he had a peevish impatience of the inconveniences of eminence." His dress was about fifty years out of fashion—a three-cornered cocked hat, a high coat collar, frilled shirt-wrists, and a faded violet suit.

* * * * *

In reading a biography one is perhaps too apt to remember a man's eccentricities. There is another side. Cavendish was a thoroughly good scientist. In all his scientific work and relations he was perfectly normal. He was a prominent member of the Royal Society, attended its meetings regularly, talked there, dined with fellow-members after the meetings, and published all he did publish in the Royal Society's Transactions. Indeed, one may say that but for his eccentricities Cavendish would have frittered away his life as an eighteenth-century buck. Instead of that Cavendish was—well, he was Cavendish.

* * * * *

Cavendish indeed was a magnificent experimenter. There is an old taunt sometimes flung against the modern physicist in his beautiful laboratory with its expensive apparatus, " He cannot see the truth for the brass." Brass and lacquer did not stand in Cavendish's light. For one thing, in his day all apparatus was crude and primitive ; for another, Cavendish's

[1] *The Scientific Papers of the Hon. Henry Cavendish, F.R.S.*, two volumes. Vol. I: *The Electrical Researches*, edited by James Clerk Maxwell, F.R.S. Revised by Sir Joseph Larmor, F.R.S., M.P. Vol. II: *Chemical and Dynamical*, edited by Sir Edward Thorpe, F.R.S. (Cambridge University Press, 12*os*. net.)

bent was towards the simplicity and informality of design that is now associated with the drawings of Mr. Heath Robinson.

* * * * *

His interest in science, and especially his desire to measure things, were almost pathological. He had remarkable insight which led him often to foretell what was going to happen in an experiment, or to guess approximately the magnitude of some effect he was about to measure. He was a great man at trying to do everything exactly. One of his greatest discoveries was that of the composition of water. His determination of the mean density of the earth (which Sir Isaac Newton had guessed at between 5 and 6) was less than 2 per cent. smaller than the most accurate result of to-day (5·53). He found that there was 20·83 per cent. by volume of oxygen in the air, and the best estimate at the present time is 20·96. In working experimentally on the capacity of a charged sphere he determined a certain ratio to be 1·57. Years afterwards Lord Kelvin proved that this ratio theoretically must be the half of π. And the half of π is 1·571. Often he was so anxious to press forward with new experiments that he did not trouble himself to publish a record of those he had finished. As these books abundantly prove, Cavendish had anticipated discoveries which, because he kept a record of them in his notebook instead of publishing them, are now attributed to the later workers who rediscovered them. Thus he prepared several chemical compounds, such as arsenic acid, which are attributed to Scheele, and forty-six years before Ohm published his work he discovered the important law in electricity which goes by the latter's name.

* * * * *

Cavendish paid great attention to electrical resistance —especially to the resistances of solutions. One of the things that puzzled Clerk Maxwell when he went through Cavendish's papers was how the latter was able to measure this. For one cannot measure electrical resistance even at the present day without some kind of a galvanometer, and the galvanometer had not been invented in Cavendish's day. The explanation is simple. Cavendish was his own galvanometer. By passing the electric current through his own body he estimated its intensity to a nicety by the shock he sustained, and in this way he sized up resistances wonderfully well.

* * * * *

It is sometimes argued that a study of the past of any science is a waste of time, since it is difficult enough in all conscience to follow it in its many ramifications to-day without saddling oneself with a study of how the facts grew into being. There is much truth in this view, but an occasional dip into the past may and often does encourage many a man to set to and do as the pioneers have done. It is the same Cambridge which gives from time to time to the world the occasional writings of her great men of science, of which these volumes on Cavendish are an example, which is to-day the most considerable centre of discoveries in pure science in the world.

* * * * *

In the long list of great men whom Cambridge has given to the world Cavendish has an honoured place. No one wants to affirm he was her greatest son. But he was a great man, a natural philosopher of the broadest possible type, who occupied himself in turn with every branch of physical science known in his time. On each he impressed the marks of his genius and the extraordinary penetrative force of his intellect.

* * * * *

The recent death of Dr. W. Warde Fowler has removed one who held a position almost unique in our own day in its felicitous union of the naturalist and the scholar. It seems almost incredible that the man whose ripe scholarship made him the recognised authority on the social evolution and the religion of Rome could also find leisure to write the only record of English rural life, in *Kingham, Old and New*, fit to rank with the immortal *Natural History of Selborne*.

* * * * *

His latest volume, a collection of some of his papers under the title *Roman Essays and Interpretations*, which we hope to notice more fully next month, contains much characteristic work. For instance, he deals with the habit, common to many Indo-European races, of associating the oak with Jupiter, the thunder-god. He shows that the sanctity of the oak is probably connected with the strange fact that this tree is more often struck by lightning than any other. If the frequency with which beech trees are struck be represented as unity, the figure for oaks is sixty. The human interest, the scholarly criticism, and the sincere love of nature which these papers show are typical of his many-sided personality. Dr. Warde Fowler will be regretted by a far wider circle than his own University of Oxford.

* * * * *

Elsewhere in this issue is printed a letter from Sir Arthur Conan Doyle bearing on my editorial remarks of last month. The question at issue is the existence of fairies. It may be said here that an argument on an important subject like this one cannot be conducted adequately in the pages of a popular magazine. It is a problem for a learned society—for authority, not private judgment. Only in such a society can a fair, an unprejudiced, and an impersonal opinion on the matter be arrived at.

Maxim Gorki

By M. V. Trofimov, M.A.

Professor of Russian in the University of Manchester

Of contemporary Russian writers, Maxim Gorki is the most representative of the spirit and tendencies of his age. He has concentrated the despair and the hope of Russia, the sense of social wrongs and evils, the horror of moral decline and the passion for regeneration, the shadows and lights of the human soul. In the penetration and vigour of his methods of analysis and description, no other Russian writer of the present time equals him.

Gorki's personality excited keen interest. His stories at once seized on the imagination by their refreshing breath of life and force of style. The general mood both in the life and literature of the time was distinctly "Chehovian." The country was enveloped in the twilight of political reaction, and the educated classes moved indifferent and aimless in the atmosphere of gloom and depression. Gorki struck a new note. He brought to the stage a new hero who scorned all intellectual conventions and challenged all established traditions. In contrast to Chehov's dim, grey, and immovable pictures of Russian life, Gorki's stories fascinated the reader by flashes of boisterous spirit, pulsations of human energy, outbursts of strong passions, and yearnings for a new ideal. The spirit of fire and revolt in Gorki's stories was a welcome contrast to Chehov's hopeless pessimism.

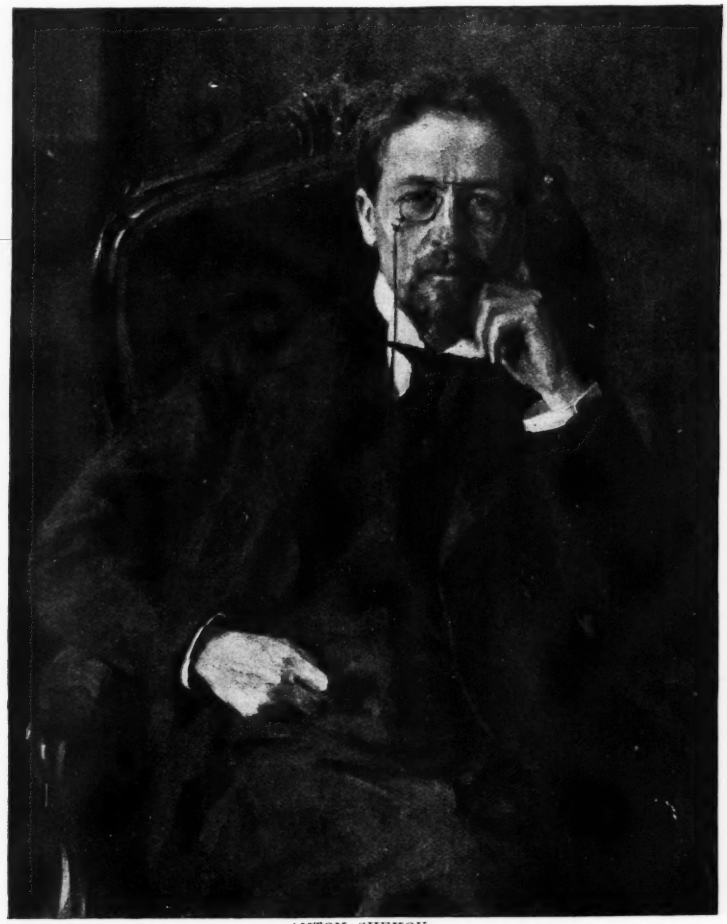
In the face of the most adverse circumstances—for he was born in a mean and poor family—Gorki has hammered out for himself a path into literature as the champion of the downtrodden and outcast. The social *milieu* which produced him and sent him forward with a message was the town democracy roused to the realisation of its own rights and aspirations. He broke the eminently rural character of Russian literature by portraying types, ideas, and emotions brought forth by the development of town civilisation. But before making workmen and tramps his chosen heroes, Gorki touched on some themes previously known in Russian literature, and in these he struck a romantic chord. His imaginative tales and legends resounded with a note of passion for the life full of vigorous emotions, unbending strength, beauty, and glory. This belief in the spaciousness, luxury, and potency of life made Gorki feel dissatisfied with the existing conditions, and led him to the idealisation of tramps and vagabonds. He represents the ragged, hungry, and shelterless vagabonds as refugees from modern civilisation which they denounce for its falseness, its suppression of natural instincts, and its trampling upon the weak and the poor. Gorki's great gift for pungent criticism and his extraordinary capacity for scorn shine throughout the vivid and biting speeches of his heroes.

Under the shabby exterior of the tramps, Gorki traced passion for freedom, love for nature, unselfishness, hatred of shams, and a great capacity for joy.

Some of Gorki's heroes are philosophic *nihilists* who have broken away from the community with the object of asserting their own freedom and becoming masters and creators of their own lives. One feels that the views and ideals they profess are those of the writer himself, who strained his imagination and violated psychological truth by dressing his idlers, thieves, and drunkards in the romantic garb of crusaders of the new humanity. Gorki assumed the attitude of the realist when he came to describe the tramps as social types, without entrusting them with a special message. Ugly and sordid is the life of the paupers and outcasts he then portrayed. Under the present order of things, they are obnoxious social refuse, worthless chaff of humanity. Like the dust raised and carried away by the wind, the wretched crowd of Gorki's outcasts are wandering through Russia's expanse, leaving everywhere traces of their sad and miserable existence. At times, the gloom of the stories is dispelled by bracing descriptions of nature, or by the rays of warm poetic feeling proceeding from the author's faith in the potent beauty of life. But with all the passion for freedom beating strongly in their hearts, the tramps are incapable of making any efforts at constructing a new life. The desire for the expression of individuality finds vent with them in drunken speeches and brawls and in criminal adventures.

When Gorki realised the inefficacy of his vagabonds, he turned his hopes towards the industrial workers. The place of action was now transported to workshops and factory quarters. He viewed the labour movement through the prism of the Marxian doctrine, coloured with his own enthusiasm for the ideals of Socialism. The worker appealed to Gorki's imagination as a man with a heart elevated by unselfish feelings, with energy and resolution, with blood rich both in phosphorus and in iron. The working class as a whole rose before his eyes as an army of labour animated by the passion for the emancipation of man. In this spirit he wrote the novel *Mother*, describing the conditions and mentality of the factory workmen. Here Gorki traced the intellectual growth of a young workman and his conversion to a new political and social faith. The general atmosphere, as well as the minute features and incidents in the life of the workman's community, are depicted with knowledge, skill, and sympathy, and the author showed his profound sense of character in painting the portrait of the peasant

mother who died for the workers' cause. In his stories, written under the fresh influence of the social-democratic ideas, Gorki idealised the factory workers by attributing to them a certain spaciousness and integrity of outlook, courage in thought and action, love for humanity, and faith in the triumph of their ideal. He lifted his working heroes above the general level, as he had previously done with his tramps. But the time came when the sense of life made him change his attitude towards his former gods. He threw off his romantic clothing and came face to face with the bare facts of everyday life. Freed of his doctrinaire creed, Gorki realised at once those depths of ignorance, poverty, humiliation, brutishness, and stupidity which form the daily life of the grey Russian masses. Continually, in the stories of Russian rural and urban life, he draws grim pictures of degradation. Describing "some incidents in the life of town Okurov," Gorki extends the sphere of his observations to the general inquiry of " What is Russia, and why is the life of the people so hard, and why are all so unhappy and convulsive, so immovable, as if they were turned into stones ? " Gorki speaks of a general decline of character prevailing in all classes of the community, and one of his men remarks that the little town Okurov, which is so deeply sunk in the morass of its stupid and uncivilised life, is only a small part of " that blissful country which has everything in abundance and lacks one thing only—common sense." The author's spokesmen are deploring the " double-naturedness of man, his moral pliancy and slavishness, his lack of faith and creative ideas," etc. Gorki feels sad at the sight of this tragic picture, but he does not become bitter or pessimistic.



ANTON CHEKOV.
(By kind permission of Messrs. Chatto and Windus.)

There is a note of optimism and enthusiasm in the words he assigned to Kozhemiakin, who says: " New

workers in the field of life have arrived; their hearts are filled with love for the earth soiled by us; they will plough up the field of God laying bare its heart, and it will shine like a new bright sun for all of us, and everybody will feel warm and happy."

No social class in Russia escaped the crushing and fatal curse of the cultural backwardness of the country. In the story *Three Days*, Gorki shows us the depths of utter misery into which the blind force of ignorance, prejudice, and drudgery has driven the peasants. Through the dim windows of wretched cottages are looking at us the ailing, suffering, and sadly obedient faces of those doomed to be ever submerged in darkness and sorrow. The story called *The Fire*, dealing with the artisan class, presents the same picture of unhappy and disorderly life, void of all sense and goodness. The minds and hearts of the industrial workers seem also to be depressed and demoralised by the cruelty, slavishness, greed, and cynicism of everyday existence. But moving in the dark shadows of dismal reality, Gorki remains ever radiant with his belief in a brighter future. He feels within himself the moving of fresh life, and there are many characters in his novels and plays who reflect the author's optimistic mood. In the story *Three Days*, the village schoolmaster, Pokrovski, gives forth this message: "Men of sincere and generous hearts are daily entering life in hundreds of thousands of villages, and some day Russia will see itself intelligent and honest. Only do not forget that God's spark shines in every human soul, and one should try and blow this spark of life into a great flame." Gorki has never lost his faith in the goodness of human nature. He sees that the ugliness and misery of life is only like a layer of dirt on the free human soul. His heroes, bruised, shaken, and disgraced as some of them are, preserve certain internal qualities which excite sympathy in the reader's heart. A hereditary and professional thief, Vasili Pepel, in the drama *The Lower Depths*, is at the same time a dreamy, sensitive, and pure man.

The source of Gorki's inspiration is his belief in the new man, who is to be free and strong and beautiful. He is thrilled by the thought of the infinite capacity of human nature. Some of his poems and sketches are exultant hymns to the glory of "tragically beautiful Man."

"Man!" exclaims Gorki. "I see his proud head and his daring deep eyes, and in them—rays of fearless, powerful thought, thought that understood the wonderful harmony of the universe, thought which in the moments of tiredness creates gods, and in the periods of activity—pulls them down."

"Possessing only the power of Thought, which is sometimes like lightning, and sometimes cold and quiet like a sword, the free and proud man walks far in front of men, towering above life."

But Gorki has created no superman. His belief in human possibility is based on his study and knowledge of ordinary man, whose divine soul calls him to live upward, "towards the vastness."

"The new man wants," he explains, "to create a new order based on the unshakable principles of freedom, beauty, and respect for men." This ideal can only be realised in the order of life free from inequality, privileges, masters and men. Gorki foresees in some distant future a reconstructed social order within which collectivism and individualism will not be "antinomies," but will form a living union and bring about a unification of the instincts with the idealistic will. Such is the present stage in the evolution of Gorki's ideas. He has arrived at worshipping collectivism and its creative power. From this it is clear why he supports Lenin in his wild experiment in changing the individualist peasant Russia into a communistic proletarian Russia. Gorki came with a "song glorifying the madness of the brave," and he thinks Lenin to be "perhaps the greatest of all madmen," but he pleads that Russia should be left alone to her madness or wisdom. "Two men are fighting on the earth against each other: the Red man and the Black man," he says in one of his tales published in June last year. "The strength of the Black man is in his insatiable thirst for power over men. The strength of the Red man is in his passionate desire to see that life is sensible and bright." And Gorki remains true to his original faith.

WORKS OF GORKI TRANSLATED INTO ENGLISH

Heartache and the Old Woman Izergil. (Maclaren & Co.)
Creatures that once were Men. Introduction by Chesterton. (Alston Rivers.)
The Outcasts and Other Stories. (Fisher Unwin.)
The Orloff Couple and Malva. (William Heinemann.)
Three of Them. (Fisher Unwin.)
Twenty-six Men and a Girl. (Greenback Library.)
Tale of Two Countries. (Werner Laurie.)
Foma Gordyeef. (Fisher Unwin.)
My Childhood. (Werner Laurie.)
In the World. (Werner Laurie.)

The Rhine Boundary and Talleyrand, 1814–15

By R. B. Mowat, M.A.

Fellow and Assistant Tutor of Corpus Christi College, Oxford

THE only Peace Conference which can be compared in importance with that of 1919 is the Congress of Vienna, in 1814–15. The organisers of the Conference of Paris had constantly in their minds the precedents

of 1814, and consciously worked to avoid the pitfalls into which, as it seemed, the diplomatists at Vienna had sometimes fallen.

Perhaps the greatest difference between the Conference of Paris and the Congress of Vienna was that at Vienna, France, against whom the Great War had been fought, was ultimately admitted as a full member of the Congress, and took part in the negotiations which led to the drafting of the various treaties of peace, including the Final Act; but at Paris, Germany was not a member of the Conference, and was presented only with the final project of the Treaty, and allowed to make written comments on it.

It is true that there was one obvious difference between the position of France *vis-à-vis* the Allies in 1814 and the position of Germany in 1919; when the Congress of Vienna opened, peace had already been made between France and the Allies (Treaty of Paris, May 30, 1814); but when the Conference of Paris opened, Germany, having only made an armistice, was still in a state of war with the Allies. Nevertheless, although France in the autumn of 1814 was technically at peace with the Allies, the Allies had no intention of admitting her as a member of the Congress, to take part in their deliberations. For over three months Talleyrand was at Vienna, and never was admitted to a session of all the four allied powers (Great Britain, Austria, Russia, and Prussia). It was not till January 9, 1815, that the Council of Four became, through the inclusion of France, the Council of Five. It is worth considering, therefore, how Talleyrand brought this about, and whether the usually received view (which is his own view) about his policy is correct.

Talleyrand's own account is given in his memoirs, and in his letters to Louis XVIII is very flattering to himself. He arrived at Vienna on September 23, 1814, and found that France was isolated. It soon became clear that there was going to be no Congress in the usually accepted meaning of the word; that the many sovereigns and governments assembled at Vienna were not going to be consulted; that the French were likely to be left completely on one side; and that the four great Allies—Great Britain, Austria, Russia, and Prussia—were going, in the persons of their plenipotentiaries, to settle things entirely by themselves. Gradually, however, a rift appeared in the grand alliance. Russia and Prussia on the one hand, and Great Britain and Austria on the other, were found to have divergent interests. Alexander of Russia meant to annex the Duchy of Warsaw (which Napoleon had created out of the former Poland); and Frederick William III of Prussia meant to annex the whole of Royal Saxony, whose king, Frederick Augustus I, had been the last faithful ally of Napoleon. Frederick Augustus had been taken prisoner at Leipsic, and his whole kingdom had been conquered, and was now occupied by Prussian troops. On the other hand, Austria was all against Prussia being aggrandised by the annexation of Saxony, and was not too friendly (nor was Great Britain) to the Russian design of annexing the Duchy of Warsaw.

This divergence of interest between Prussia and Russia on the one hand, and Great Britain and Austria on the other, became so acute that the great Allies at Vienna practically divided themselves into two camps; and open war between them was threatened. In such a situation, France had obviously the opportunity to hold the balance; she had still a powerful army, which might turn the scale if thrown vigorously on one side. Talleyrand was just the man to use this opportunity, and so well did he do so that, after receiving various offers from both sides, he finally accepted a military alliance with Great Britain and Austria. On January 3, 1815, Castlereagh and Metternich signed a secret treaty with their former enemy, engaging each one of the three to defend each other, and to put 150,000 men in the field if any threat of attack were made against them. Thus France gained admittance to the councils of two of the chief Allies at the Congress of Vienna. Furthermore, she was admitted to the formal meetings of all four Allies on January 9. Henceforth there was no longer a Council of Four, but a Council of Five. The solid front shown by Great Britain, Austria, and France induced Prussia and Russia to give up a good portion of their pretensions in the Saxo-Polish question. In particular, the King of Saxony was left on his throne at Dresden, with about half his former territory, Prussia having to content herself with annexing only the other half.

Talleyrand takes great credit to himself for thus raising France, so soon after her defeats in the war, to be one of the five controlling powers of Europe. And he writes triumphantly, and quite truthfully, to Louis XVIII at Paris that the anti-French coalition no longer exists: "Maintenant, Sire, la coalition est dissoute, et elle l'est pour toujours" (*Correspondance Inédite*, p. 209).

The disruption of the anti-French coalition, and the admission of France to the Concert of Europe—these are the gains of Talleyrand at the Congress of Vienna. But how did France pay for these gains? She appears to have paid for them by giving up her territorial security, and by putting herself in a position which, in the long-run, made it inevitable for her to fight the wars of 1870 and of 1914.

The reason for making this statement is as follows: On December 29, 1814, while Prussia was still bent on annexing the whole of Saxony, Hardenberg, the chief Prussian delegate, sent to Metternich a specific offer to indemnify the King of Saxony for the loss of his

kingdom by setting him up in a new kingdom on the left bank of the Rhine. This new kingdom was to consist of the Duchy of Luxembourg, a part of the Archbishopric of Trèves (including the city of Trèves itself), and the southern portion of the Archbishopric of Cologne, including the town of Bonn, and the Abbeys of Prüm, Stavelot, and Malmédy. The territory thus to be assigned had a population of 700,000 (D'Angeberg, p. 1863).

The same project (which appears really to have been due to the Tsar) was put before the Council of Four in the form of a draft treaty on December 30 (ibid., p. 1869).

Metternich and Castlereagh rejected this proposal, for very obvious reasons—Metternich, because the annexation of Saxony by Prussia would destroy Austrian preponderance in Germany; Castlereagh, because the British Government did not wish to see a client state of France (which was still felt to be a danger to Europe) established so near to the Low Countries and the mouth of the Rhine (Castlereagh to Lord Liverpool, January 5, 1815, in Wellington, *Supplementary Dispatches*, ix. 528). Talleyrand also rejected the proposal when it was communicated to him, and instead he accepted the offer of Castlereagh and Metternich of a military alliance with GreatBritain.

That the project of setting up the King of Saxony on the left bank of the Rhine was communicated to Talleyrand, he himself acknowledges. He describes the project in a letter of January 3, 1815, to King Louis XVIII. In another letter, of January 6, to the King, he says that the Tsar has sent Pozzo di Borgo to Paris to gain Louis' consent to the project; and he goes on to state his objections to it, viz. (1) that it is against the principle of legitimacy; (2) that it would change the relative strength of Austria and Prussia. To Castlereagh Talleyrand expressed himself "with great propriety"; ambition and the idea of conquest inclined him to accept the Tsar's project, but he desired to put a restraint on any extension of the existing boundaries of France (Castlereagh to Lord Liverpool, January 5, 1815, in Wellington, *Supplementary Dispatches*, ix. 528).

To suppose that Talleyrand really had these scruples is mere nonsense. His whole career proves the contrary. The truth is clearly that he preferred to accept the offer of the Anglo-Austrian Alliance, and thus to get France, lately so defeated, into the position of one of the arbiters of Europe. But at what a price! For if he had accepted the Prusso-Russian offer; if the King of Saxony had been established in a buffer state on the left bank of the Rhine, Prussia would never have been the danger she became on the north-eastern frontier of France. *The Prussian and French frontiers would not have touched each other.* It was because Prussia was forced to give up her claim to the whole of Saxony that she was indemnified by being allotted territory on the left bank of the Rhine. As the most recent historian of France says: "It seemed that France had gained a great success. However . . . it had been necessary to sacrifice the tranquillity of the French frontier" (Charléty, p. 40).

It only remains to ask whether Talleyrand could have accepted the Prusso-Russian project, in spite of the opposition of Great Britain and Austria. Castlereagh was determined to employ all the military strength of Britain to defeat the proposal, but it is very doubtful if he could have prevented it. For Prussia and Russia had extremely powerful armies, and France was by no means helpless. In a war to safeguard the left bank of the Rhine, recruits would have flocked to the standard as readily as they came to Napoleon's when he returned from Elba two months later. "The line of the Rhine, Belgium, Luxembourg alone, would make recruits abound" (*Jaucourt to Talleyrand* in Charléty, op. cit., p. 41).

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The Daylight Micro-Projector

An Optical Apparatus, invented by a French Physicist, which dispenses with the use of Lantern Slides and is of invaluable use to Lecturers and Others

By G. Frederic Lees

ONE of the most recent meetings of the French Academy of Sciences was noteworthy on account of a communication made by M. Branly on the subject of a remarkable optical apparatus, invented and recently perfected by M. Dussaud, which is calculated to render invaluable assistance to lecturers and others who, for the purpose of supporting their remarks by means of documentary evidence, require to throw on the screen

photographic or other illustrations. The ordinary magic lantern used at lectures and other demonstrations requires darkness and specially prepared lantern slides, but the " dussaud," as the inventor has elected to call

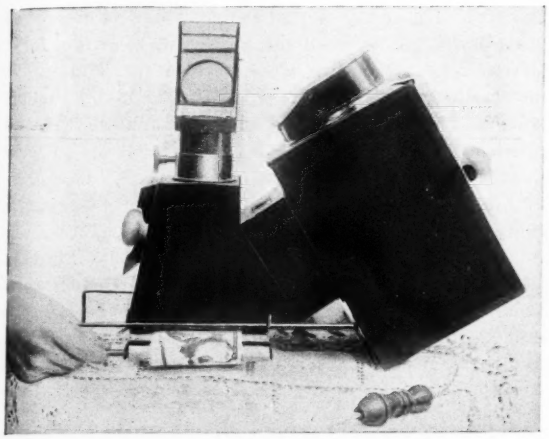

FIG. 1.

his apparatus, is operated in the full light of day, and is so constructed that any object of a size that can be introduced into the apparatus can be projected on to the screen or anywhere in the room where the demonstration is taking place. This enables the members of the audience to take notes and saves the great cost of making lantern slides.

Before giving a detailed description of the photographs which illustrate this article and the various uses to which the " dussaud " can be put, let me state the principles upon which the lantern is based, in accordance with the official communication made to the Academy of Sciences.

The maximum of luminous efficiency has been obtained by means of condensers with one or several lenses, the focus of which has been calculated by M. Dussaud in relation with that of the reflectors at the back of the source of light, and in such a manner as to make it as short as possible—in certain cases not more than 5 centimetres. In this way the whole of the light is concentrated by reflection on the object to be lit up and projected. M. Dussaud claims—and the demonstration before Parisian scientists proves his contention—that his optical systems realise the conditions of precision and yield of microscopes, and constitute, in fact, collective microscopes. With half-watt electric lamps, only 3 amperes from a voltage of 110 volts (the minimum quantity of voltage supplied by Parisian electric-light companies) suffice to project objects with their form, colour, relief, and movements, the dimensions of the projection being as large, if necessary, as 9 square yards either on a screen or on any vertical, horizontal, or oblique surface. The apparatus is very easy to use, and its small size and weight enable it to be held in the hands in all positions. For home use it is admirable, since it can be connected with the electric-light current by means of any ordinary plug. The apparatus is cooled by circulation of air around the lamp, the optical system, and the object to be projected, the temperature not rising above 25° Centigrade (77° Fahrenheit) after the apparatus has been in use for a quarter of an hour. The object to be projected is placed at the base of the apparatus, which thus forms a sort of laboratory table fully lit up and the dimensions of which, according to the type of apparatus used, are 6 cm. by 6 cm., 12 cm. by 12 cm., or 24 cm. by 24 cm.

M. Dussaud has devoted seven years to the solution of the problems which this apparatus set him. He was, indeed, faced by a triple problem : a mathematical one through the calculation of the curves, a chemical one through the composition of the matter used, and a physical one through the calculation of the indices of refraction, " because he considered that such an optical system, enabling one to see objects enlarged up to 125,000 times *in volume*, in a fully lighted room, would render the greatest service to science."

We will now examine, in the light of the illustrations, the various uses to which the " dussaud " can be put.

Fig. 1 represents its use with two cylinders, on which is unrolled and rolled a spool of paper bearing illustrations or a text which have to be projected. The lamp and its reflector is in the box on the right, and the light is thrown on to the images as they are unrolled by the hand of the lecturer. Above them is a combination of

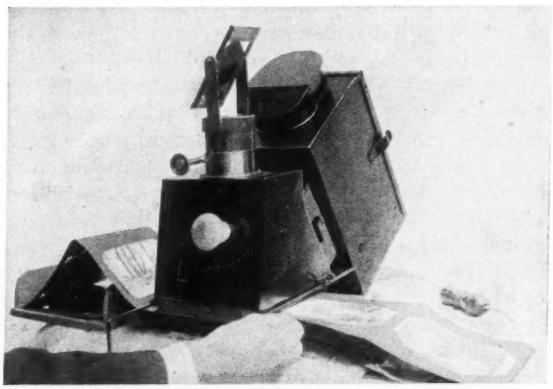

FIG. 2.

lenses which throws the pictures on to a mirror which swings on an axis, and it is this mirror which projects the illustrations on to the screen or wall or ceiling, according to the angle at which the mirror is set. It is because of this ingenious arrangement that projection

is possible in a fully lighted room ; there is no luminous cone, as in the case of an ordinary projection lantern

FIG. 3.

worked in a darkened hall ; and when the projection is made on a suitable screen and the images shown are pictures from Art Galleries, they have all the appearance of being the works of art themselves.

Fig. 2 shows the apparatus when used with a folding album in which picture postcards, reproductions of paintings, etc., have been pasted or otherwise fixed. As in the previous instance, the correct focussing on to the screen is done by means of the rack and pinion with which the lenses are provided. It will be seen that the space underneath the portion of the lantern which is lit up is sufficiently great to allow an open book to be slipped under. This is of the greatest utility to lecturers, who so often need to support their remarks by reference to an illustration or a diagram in a work of authority—an illustration or diagram which, in the case of an ordinary projection lantern, would necessitate the making of a lantern slide. The multitudinous uses to which the " dussaud " lends itself in this connection will occur to the reader. I need mention but two or three, such as scientific gatherings, lectures before military students, board meetings, demonstrations in clinics, etc.

To project an object, say a necklace of beads, it is introduced into the apparatus through the door. To protect the eyes of the lecturer from the intense light which pours on to the object when this is done, a mobile screen with a piece of dark-coloured glass in the centre is hooked on to the top of the box, so that no light escapes. This enables the demonstrator to see what he is doing. It is when the apparatus is in this form that it renders the utmost service to the lecturer on natural history, the engineer, or commercial traveller. Natural history specimens can be introduced with the greatest ease and enlarged to a size which shows their anatomy, movements, colour, habits, etc., in an altogether astonishing manner. Collectors of engravings, numismatists, philatelists, jewellers, and, above all, financiers will find M. Dussaud's invention of particular value in this form. I may add that it was recently used at a great Parisian bank for the projection of bank-notes and cheques, some of which were believed to be forgeries, and the spurious notes or altered cheques were, thanks to projection, detected with the greatest ease in the presence of a number of experts.

Fig. 3 shows the inventor holding his apparatus and projecting a sketch wherever he likes: on to the ceiling, on to a wall, or above a doorway. It is when the apparatus is used in this manner that it will be found of the greatest use to architects or artists who wish to judge of the effect of a given piece of decoration, say, in the corner of a room just underneath the ceiling. And the effect can be judged, with all the colours of the little sketch which is being projected shown, under natural conditions of lighting, that is to say, in the full light of day. Architects need no longer resort to the stencilling of their designs, to the squaring off of their drawings, to the camera lucida, to the pantograph, or to other mechanical means of enlarging their sketches. All that one has got to do is to project the design on to the spot chosen, and then sketch it in.

Fig. 4 represents (from left to right) the four elements of which the " dussaud " is composed. On the left is the box containing the lens and bearing at the top

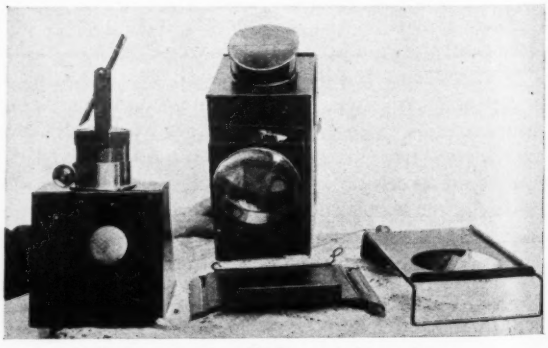

FIG. 4

the mobile mirror. In the middle at the back is the box containing the luminous source—a box which fits on to the preceding one. In front of it is the support for the passing of illustrations, etc., under the shaft of light, with its two rollers. And on the right is the support for the apparatus when it is necessary to raise it from the table to a sufficient height to enable a book to be slipped underneath.

These four elements may be put together and arranged in different ways for particular purposes.

For example, the elements of the "dussaud" may be combined in such a manner as to project any object or any action which can only be shown in the vertical plane, such as the action of pouring a liquid from a drop-bottle, the burning of a match, etc.

The elements of the lantern may also be combined to project any transparent object, such as ordinary lantern slides and coloured photographic plates.

It should be mentioned that by using two daylight micro-projectors and two resistances (to vary the electric current and therefore the intensity of the light), dissolving views of the greatest beauty (flowers, insects, precious stones, etc.) can be obtained, as with glass slides.

A Roman Gentleman

By W. R. Halliday, B.A., B.Litt.

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THE private correspondence of a prominent personage of a past era is never without interest, shedding, as it must do, an intimate light upon the society in which the writer moved. If the man of affairs be also a man of letters, if he be a Horace Walpole or a Pliny, there is an added pleasure in its study.

The Younger Pliny, as he is generally called, was born at Como in A.D. 61 or 62. Though belonging to the Italian rather than to the Roman aristocracy, his family was well-to-do and had been of local importance for several generations. His guardian, for his father died when Pliny was a boy, was Verginius Rufus, the most distinguished general of his day, a man who had twice refused the wishes of his troops to make him a candidate for the imperial throne. He was adopted as his heir by his uncle Pliny the Elder, the scholar and antiquary who met his death, a martyr to his scientific interest, in the great eruption of Vesuvius which buried Pompeii and Herculaneum in A.D. 79. After studying under the great professor of rhetoric, Quintilian, Pliny was called to the Bar and rose to distinction upon what we should call the Chancery side. He was clearly an indefatigable worker, careful, even meticulous, in his attention to detail. In several important cases arising from charges of provincial misgovernment, Pliny was retained for the prosecution, and when in A.D. 111 the Emperor Trajan found it necessary to send out a special commissioner to reform the administration of Bithynia, which had fallen into grave disorder, Pliny, whose conduct of these cases had given him considerable knowledge of provincial administration in general, and, as it happened, of Bithynian conditions in particular, was wisely selected for the task.

The correspondence, then, consists of the letters of a leading barrister and a distinguished public servant who was born in the middle of the reign of Nero and died shortly before A.D. 125. Except for those which as special commissioner he exchanged with the emperor, and which throw an invaluable light upon the provincial administration of the period and incidentally upon the attitude of the Roman Government towards the rising sect of Christians, the main interest of these letters is not political. It lies rather in the characters of the writer and his friends; and the qualities which they display are not the less remarkable because Pliny is self-revealed as in no sense an exceptional personality but as one man whose character reflects the virtues of his type and class. For the impression of society which Pliny gives us is very different from that popularly derived from novels like *Quo Vadis* or cinematograph representations of Christians in the arena. It is different, again, from that conveyed by the satirist Juvenal, whose material was the same society, but who saw it from the different angle of Grub Street or from that presented in the gloomy masterpiece of Pliny's friend Tacitus. Now, it may be true that Pliny does not give us the whole picture, but neither do satirist or historian, and it is pleasant to be reminded by these letters that Rome possessed an upper class many of whose members were cultured, humane, upright, kindly, and generous.

Pliny, of course, has his weaknesses. He is patently vain about his literary compositions and his eloquence in the courts. But he is so frank about it that he disarms criticism, and if he thoroughly appreciates the merits of his own compositions, he is equally generous towards the literary efforts of his friends. He expects them to sit through and applaud the interminable recitations of his speeches or verses, but he is himself punctilious to form part of a friendly audience for them in turn. He is at times a bit of a prig, but he recovers himself with a fine tolerance. "Let us, then, make allowances for what pleases other people, so that we may induce others to make allowance for us!"

Of his upright character he gives us more than one illustration. Although a lawyer by profession, he is never anxious to press the strict letter of the law to the detriment of equity. For instance, a friend, half of

whose property he inherited, had left written codicils which for formal reasons were not legally valid. "I have made a law of my own for such cases," writes Pliny, "which leads me to treat as valid the wishes of the dead man, even though they are not legally binding upon me." In business matters, too, he acts with generosity. Dealers upon one occasion had bought up his vintage in prospect. The crop and market failed them and they were faced with considerable loss. Pliny thereupon very generously remitted an eighth of the purchase price to all, making additional remissions to those who had been the largest buyers.

His relations with his servants are marked by kindness and humanity. There were, of course, brutal masters. Pliny tells of the fate of one who was murdered by his exasperated slaves in the bath, and refers to another acquaintance who set out upon a journey and mysteriously disappeared, while the servants who accompanied him were never seen again. But Pliny can have had little to fear from his "family." His slaves are not chattels, but human beings and humble friends. "I have been greatly upset," he writes, "by illness in my household, some of my servants having died and at an early age. I have two consolations which, though they are by no means equivalent to my grief, do certainly afford me comfort. One is that I have been generous in giving them their freedom—for I do not consider that I have lost them altogether immaturely when they died free men—and the other is that I allow my slaves to make as it were valid wills, and I preserve them as I should strictly legal documents. But though I have these consolations to make my mind easier, I feel shattered and broken by just that same sense of common humanity which led me to grant them these indulgences."

There are constant references in his letters to his solicitude for his freed-men, his affectionate appreciation of their good qualities and his anxious care for their welfare. Zosimus, a favourite reader and comedian, is sent to Egypt for a cure, and upon a recurrence of his malady, Pliny sends him to a friend's farm, where he can hope to benefit from the country air and good milk. His old nurse he pensioned off with a small property, and begs a friend to look into the business side of it for her.

Pliny's relations with his young wife are wholly delightful. Their happiness was only clouded by the lack of children which they ardently desired. Although much younger than her husband, whose third wife she was, Calpurnia threw herself completely into his interests. "I feel perfectly assured," he writes to her aunt, "that our mutual happiness will be lasting and will continue to grow day by day." When she is absent, Pliny is miserable. "It is incredible how I miss you," he tells her, "such is the tenderness of my affection for you and so unaccustomed are we to a separation! I lie awake the greater part of the night in conjuring up your image, and by day (to use a very common but very true expression) my feet carry me of their own accord to your apartment at those hours I used to visit you; but not finding you there, I return with as much sorrow and disappointment as an excluded lover. The only intermission my torment knows is when I am engaged at the Bar and in the causes of my friends." This charming picture of domestic happiness is a pleasant corrective to Juvenal's savage onslaught on the monstrous "regiment of women" in his sixth satire. Nor was Pliny's case a unique phenomenon in Roman society. His friend Macrinus and his wife had "lived together for thirty-nine years with never a quarrel or disagreement" before death separated them.

Pliny had clearly a genius for friendship. He has a genuine affection for his friends, and his sympathy in their joys and sorrows is patently sincere. He is always ready to do anything for them, and will not spare himself in their service, whether it be the exercise of political or professional influence in their favour or the selection of a tutor or a husband for their children. He tends to see the best of people; his appreciations are warm, his testimonials glowing.

He shows, too, a nice feeling. He is particularly fond of helping and encouraging the younger men in his own profession. With money he is extremely generous, and what is more, shows a delicacy in the manner of his giving. The daughter of his old teacher, Quintilian, was being married to a man of some position, and her dowry, so Pliny tells her father, should be sufficient to enable her to maintain her rank. "Now, as I am sensible your material wealth is not equal to the riches of your mind, I claim to myself a part of your expense and, like another father, endow our young lady with 50,000 sesterces. My contribution should be larger but that I am well persuaded the smallness of the gift is the only inducement that will prevail with your modesty not to refuse it." To a lady who had discovered and offered to rectify a generous deceit by which Pliny had charged her 700,000 sesterces for a property assessed for revenue at 900,000, he replies, "I must desire and insist in my turn that you will consider not only what befits your character, but also what befits mine and will suffer me to oppose your inclination in this single instance with the same warmth that I obey it in all others."

If his purse was always open to relieve the wants of a friend or dependent, Pliny was no less generous in public benefaction. His native place was very near his heart, and though Como was not the sole recipient of buildings at his expense, it is to his birthplace that his most interesting gifts were made—the creation of a library and the endowment of a fund for its upkeep, the provision of a fund for the education of poor children

and the creation of a school. In the age of the Antonines, as in our own, the wealthy recognised the responsibility of their riches and were generous givers. The tendency of the time was towards the increasing provision of public institutions for the care and education of children, the encouragement of maternity, and the maintenance of the aged and infirm. It is interesting to notice, however, a marked difference of opinion between Pliny and a recent benefactor of Scottish universities. The inhabitants of Como had previously been obliged to send their sons to Milan for want of a local school. Pliny determined to remedy this. He initiated the scheme for creating a good local school, and spent some trouble, enlisting the help of Tacitus in the matter, upon securing an adequate staff. But he shrewdly refused to find more than a part of the endowment necessary, not because he grudged the money, but because in his view, as he told his fellow-townsmen, parental responsibility counts for something, and people value more and take a more efficient interest in an institution to the cost of which they contribute themselves. "For though parents may be careless in disposing of another's bounty, they will certainly be cautious how they apply their own, and will see that none but those who deserve it shall receive my money, when they must at the same time receive theirs too."

It will be seen that the general reader who turns to Pliny's *Letters* for the first time will be likely to modify his conception of the manners and morals of pagan aristocracy at the turn of the first and second centuries. He may also find plenty of entertainment and plenty of good things in the book. There are interesting vignettes of social types like the well-read country gentleman (viii. 25), or the eccentric old lady of lurid tastes with her private company of farce-actors and her exemplary grandson (vii. 24). There are charming sketches of Italian country written with a feeling for scenery which is rare in classical authors. There are the two letters to Tacitus describing at first hand the great eruption of Vesuvius. There is a famous ghost story, and finally there is the marvellous relation of the wonderful dolphin of Hippo (ix. 33), a theme which is worthy, though I do not think he has made use of it, of the treatment which Anatole France alone could give it.[1]

[1] Handy and inexpensive pocket editions of Pliny's *Letters* are the translation by J. B. Firth, published by the Walter Scott Publishing Co., and the text and translation edited by W. M. L. Hutchinson for the Loeb Library. Though I have made use of both above, the second is perhaps preferable, for not only does it give the Latin text opposite the translation, but the latter is a revision of an English classic, the translation of William Melmoth first published in 1746.

For the social conditions of the period Dill, *Roman Society from Nero to Marcus Aurelius*, and Friedlaender (translated by Magnus), *Roman Life and Manners under the Early Empire*, may be consulted.

Recent Advances in our Knowledge of the Sun

By the Rev. Hector Macpherson, M.A., F.R.A.S., F.R.S.E.

SOLAR astronomy, as a distinct branch of the science, dates from the closing years of the eighteenth century. The elder Herschel, amid his multifarious investigations, found time for the systematic study of the solar disc; and to him is due the credit of enunciating, as the outcome of his scrutiny of the spots and faculæ, the first "solar theory" worthy of the name, a theory which, although fallacious, acted as a stimulus to further investigation. In the history of solar research since Herschel's time, three well-defined periods may be traced. The first, which may be designated the telescopic period, opened in 1826, when Heinrich Schwabe, the amateur astronomer of Dessau, began to count the number of spots visible daily on the solar disc, an investigation which ultimately resulted in the discovery of the solar cycle—the increase and decrease of the number of sun-spots in a period of about eleven years—which was shown to be synchronous with the period of terrestrial magnetic variation. In this period, too, Carrington, in England, and Spörer, in Germany, independently discovered the remarkable equatorial acceleration of the sun. They showed that the sun's rotation period increased from about 25 days at the solar equator to about 27½ days midway between the equator and the poles.

The second, which may be called the spectroscopic period, opened in 1859, when the newly-invented spectroscope was applied by Kirchhoff to the study of the sun, and the sub-science of solar physics was born. By means of the spectroscope many of the familiar terrestrial elements were identified in the solar atmosphere. The spectroscope was also applied by Janssen and Lockyer to the daylight study of the solar prominences, those red flames which were formerly revealed only on the rare occasions of total eclipses. The systematic work of the Italian school of spectroscopists—Secchi, Respighi, Tacchini, and Riccó—brought out the significant fact that the number and distribution of the prominences were governed by the same law as the spots; in other words, obeyed the solar cycle. Perhaps, however, the application of the spectroscope to the measurement of motion was the most important development during this period. In 1842 Christian Doppler, of Prague, pointed out that, theoretically, the colour of a luminous body should be changed by motion of approach or recession, just as the sound of a sonorous body is altered; the change in colour, how-

ever, is so slight as to be imperceptible; what actually happens is a slight shift of the entire spectrum in one direction or another. There is, therefore, a displacement of the spectral lines in one direction if the source of light is approaching, and in another direction if it is receding. The application of Doppler's principle to the measurement of the rotation and atmospheric motions of the sun was one of the epoch-making advances in this period. In the hands of Dunér, the Swedish astronomer, the spectroscope confirmed the discovery by Carrington and Spörer of the sun's equatorial acceleration, and indicated that its rotation period was protracted to about thirty-eight days near the poles. Measures of the velocities of prominences were also secured by Young and others.

In 1891 the third period of solar research was inaugurated. It may be called the spectroheliographic period, from the instrument which in that year became the invaluable adjunct to telescope and spectroscope. The spectroheliograph was devised independently by Professor George E. Hale, now director of the Mount Wilson Observatory, in California, who was then in charge of a private observatory near Chicago, and by M. Henri Deslandres, of Meudon, near Paris. The principle of the spectroheliograph has been lucidly explained by Professor R. A. Sampson, in his admirable little monograph *The Sun*, in the following words: In a spectrogram, or photograph of a spectrum, "each line is a record of the presence and state of a separate chemical element at the spot of the disc to which the slit is directed. If this record could be read for that special line for the whole disc, we should have the same information summed up for the whole sun. . . . Let the light from the line in question be allowed to pass to the photographic plate, by means of a second slit, at the focus of the camera, the jaws of which shut off all the rest of the spectrum. Let both the first and the second slits be long enough to extend right across the image of the sun. Move the image of the sun across the first slit, then the light which passes through the second slit will come at every moment from different strips of the sun's surface; and if the photographic plate be moved behind the second slit, in unison with the movement of the sun's image across the first slit, a record will be given, not of the radiations of every substance mixed together, as in ordinary photographs or visual observations of the sun's disc, but of the states of some isolated substances as calcium or hydrogen, and even of different strata of these."

The early work both of Hale and Deslandres was largely experimental. Both astronomers were handicapped by limited opportunities and instrumental means. In 1908, however, on the assumption by Deslandres of the post of director of the Meudon Observatory, that institution was thoroughly re-equipped, and the director began the construction of a large spectroheliograph "to reveal the superior layers of the chromosphere[1] by the aid of the light of calcium and hydrogen." In addition to the spectroheliograph, Deslandres devised an instrument which he called the "spectro-enregisteur des vitesses"—the velocity-recorder. With this form of spectroheliograph it is possible to determine, by means of Doppler's principle, the radial velocities all over the disc, indicating which vapours are ascending and which are descending. As a result of the work of Hale, Deslandres, and other observers—notably those working under Hale at Mount Wilson—it is now possible to speak as Deslandres has done of the "progressive revelation of the entire atmosphere of the sun." The last twenty years have been a period of unparalleled progress in solar astronomy. The new methods, for instance, have thrown a flood of light on the nature of the solar spots. These spots were among the first-fruits of Galileo's little refractor, and have been under telescopic observation for over three centuries. It is indeed somewhat remarkable that, although they were observed carefully for two hundred years by astronomers of such consummate skill as Cassini, Wilson, and the elder Herschel, their periodicity was not discovered until Schwabe, with a small hand telescope, began to count their numbers from day to day. The telescope, unaided by its modern adjuncts, however, was of little use for fathoming the mystery of the constitution of the spots. For many years Wilson's classical theory of the nature of the spots was widely accepted. This hypothesis, which was adopted by Herschel, maintained that they represented depressions below the surface of the solar photosphere. Careful observation in the latter half of the last century, however, led a number of competent investigators first to doubt and latterly to challenge the accuracy of the theory. In 1904 the late Professor C. A. Young, of Princeton, cautiously pointed out that "as regards the sun-spots it seems no longer safe to assume that they are always depressions in the photosphere." More definite was the conclusion reached by Dr. Abbott in 1911, that "it seems most probable that the level of the sun-spot phenomena seen by ordinary observers differs very little, if at all, from that of the surrounding bright surface of the sun."

By 1903, the development of the spectroheliograph permitted the photography of hydrogen clouds as well as calcium. In the spring of 1908 Hale, at Mount Wilson, made the interesting experiment of photographing the sun in the red light of hydrogen. These photographs revealed whirling storms in a region of the solar atmosphere higher than that of the calcium and

[1] The photosphere is the luminous envelope of the sun. The chromosphere is the gaseous envelope of the sun through which light passes from the photosphere.

lower hydrogen clouds. This gave strong support to the hypothesis of the vortical nature of sun-spots. "We know now," said Hale in November 1908, "that they are caused by vortices in the solar atmosphere, and the various theories which do not recognise this fact may be laid aside." At that time, Hale inclined to the view that "in the case of sun-spots we see a phenomenon somewhat analogous to a tornado or waterspout on the earth. If the gases at high levels whirl with sufficient velocity, they develop a tube-like extension which reaches down through the comparatively undisturbed gases at lower levels. At the centre of the storm the expansion of the gases due to their rapid rotation cools them and thus produces a comparatively dark cloud which we see in the sun-spot." At that time Hale believed the disturbances giving rise to the spots to have their origin in the upper regions of the solar atmosphere. This view he modified later.

Experiments conducted by Rowland at Baltimore as far back as 1875 indicated that, if electrically-charged bodies existed at all in the solar atmosphere, their revolution in sun-spot vortices would produce a magnetic field; and in 1896 Zeeman, of Amsterdam, showed that the light from a luminous vapour is altered in a remarkable way when under the influence of a strong magnetic field—the lines of the spectrum being widened or broken up into several constituents (the Zeeman-effect). With the aid of the 30-foot spectroheliograph of the Mount Wilson Observatory, Hale, in 1908, closely scrutinised the spectra of sun-spots for traces of the Zeeman-effect, and his scrutiny was soon rewarded by the discovery that the double and triple lines in these spectra are exactly similar to the lines produced by the presence of a magnetic field. In the annual report of the observatory for 1909, Hale was able to announce that the existence of magnetic fields in sun-spots "has been placed beyond doubt through

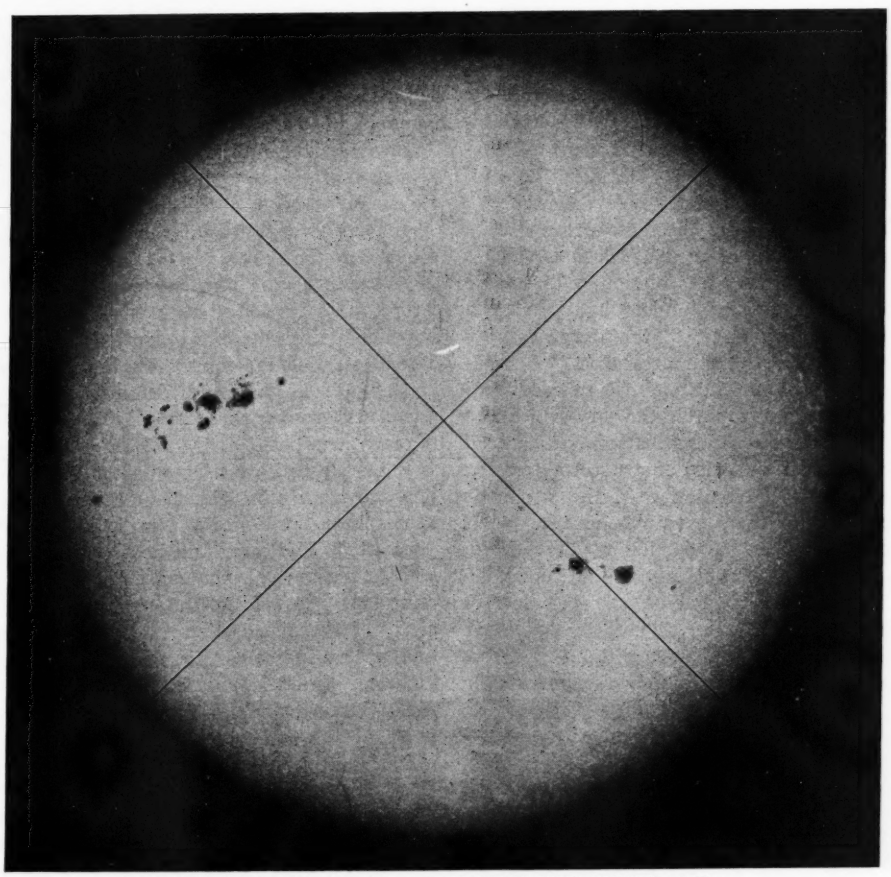

PHOTO OF SUNSPOTS TAKEN AT GREENWICH OBSERVATORY, MAY 1921.
(By kind permission of the Astronomer Royal.)

the detection of all the characteristic phenomena of the Zeeman-effect. As the only known way in which such magnetic fields could be produced at the temperature of the sun, it thus appears probable that sun-spots are electrical vortices."

In 1909 a brilliant discovery was announced by Mr. John Evershed, the able English astronomer who directs the observatory at Kodaikanal, in India. He detected displacements of lines in the sun-spot spectra, which indicated, on Doppler's principle, the existence of large radial motions in spots—the movement of gases outward from the centre of the spots and parallel to the photospheric surface. In the summer of 1910, Dr. C. E. St. John, at Mount Wilson, commenced a more elaborate investigation, and after two years he confirmed Evershed's discovery and put forward a hypothesis of its significance. "We are dealing," he said, "with an actual flow of the material of the reversing layer out of spots and of the chromospheric material into spots." In the light of these disclosures, Hale's original sun-spot hypothesis was obviously untenable or at least only partially true. Accordingly, in 1912, he outlined what he called a "tentative working hypothesis" as "a guide to further research." According to this theory a column of gas moves upward from the interior of the sun towards the surface of the photosphere. Owing to differences of velocity of adjoining surfaces or irregularity of structure, a vortex motion is set up. The circulation in the vortex is vertically upward and then outward. As a result of expansion in the central portion of the vortex, cooling sets in, and a comparatively dark cloud—the sun-spot umbra—is formed. "A rapid flow of negative ions sets in towards the cooler gases at the centre from the hotter gases without. These ions, whirled in the vortex, produce a magnetic field."

The systematic study of the chromospheric regions—comprising prominences, faculæ, and the higher levels of the solar atmosphere—has been carried on in recent years by Deslandres, Evershed, and the Mount Wilson observers. Evershed's work on prominences has supplemented the earlier work of Tacchini and the Italian spectroscopists. From 1890 to 1906, observing in England, Evershed recorded 11,000 prominences, and from the commencement of his work in India until 1917, 60,000 were numbered and investigated. Evershed confirmed the conclusion of the Italian astronomers with regard to the general identity of the prominence-period with the spot-period. He distinguishes two classes of prominences—"large high prominences" and "prominences associated with sun-spots." The large and massive prominences are not found directly above spots, while prominences of the second type are invariably associated with these objects. The application of the spectroheliograph has now made possible the observation of prominences not only on the edge of the sun, but all over the disc. Allied to the prominences are filaments and alignments in the higher regions of the solar atmosphere to which Deslandres has devoted much attention since 1906. These form a kind of network over the disc. Again and again, Evershed has noticed that at a point of the limb where a prominence is visible, a filament or alignment usually ends. Evershed, indeed, identifies filaments with prominences projected on the disc of the sun. Indeed, prominences, alignments, filaments, faculæ, and flocculi seem to be different varieties of the same species, at different depths of the solar atmosphere and of varying degrees of permanence. Undoubtedly the most ephemeral of all solar phenomena are the hydrogen "bombs," first noticed by Mr. Ellerman at Mount Wilson on September 21, 1915. The average duration of these is from one to three minutes, and on rare occasions from five to ten. "The appearance of the phenomenon," wrote Ellerman in 1917, "indicates something in the nature of an explosion, in which hydrogen seems to be the only element playing a part. . . . The regions where the bombs are likely to appear are around and among active spot-groups, especially groups which are developing and composed of many members."

Research work on selected areas and different levels has enormously increased our knowledge of the solar atmosphere, and of its components and circulatory processes. The rarer and heavier elements appear to be confined to the lower levels and the lighter and more abundant gases form the upper layers. St. John's study of the distribution of the elements in the solar atmosphere indicates that the lower solar atmosphere, including the lowest region of the reversing layer, is a highly disturbed region, in which are located the upper parts of the sun-spot vortices, where the outflow of material from the interior takes place. Higher than this is the general reversing layer, and higher still the chromosphere. Beyond the chromosphere is the corona. Unlike the chromosphere, this outer envelope is always screened from view except on the rare occasion of a total eclipse of the sun. Many attempts have been made, by various methods, to photograph the corona in daylight, but these have been so far without success. At an early stage, it became apparent that the shape of the corona is governed by the solar cycle. At maximum the coronal radiance is equally distributed all round the sun's disc, while at minimum long streamers from the equatorial zones make their appearance. The study of the corona has made much less progress than that of other solar appendages, and accordingly its nature is still largely a matter of conjecture. The coronal spectrum was long ago noticed to be com-

pound, indicating that it shines partially by reflected light from the photosphere and partly by its own inherent light. It has been generally conceded that electrical action has much to do with the nature of the corona, though Arrhenius and others have insisted on the part which radiation-pressure plays in its production. Professor Perrine, in 1918, expressed the view that the matter composing the corona, with the exception of the portion which gives a bright-line spectrum, exists in the form of small solid and liquid particles, and that this matter shines by its own radiance, while the outer corona shines by reflected light. The greater part of the motions within the corona, according to Perrine, is due to mechanical causes, explosions, light-pressure, and gravity, while he holds that the view that the arrangement of the coronal streamers results from magnetic and electrical causes is not improbable. During the total solar eclipse of June 8, 1918, the Lick Observatory expedition, headed by Professor Campbell, secured a number of photographs which revealed arches of coronal matter surrounding the principal prominences, indicating the probability that the structure of the corona is largely dependent on the forces producing the prominences. That these forces are in great measure electrical and magnetic admits of little doubt.

In two papers, published in 1904, Mr. E. W. Maunder, of Greenwich, brought out some remarkable facts concerning the connection between the sun-spots and terrestrial magnetism. In the first paper he showed that, "of the nineteen great magnetic storms recorded at Greenwich from 1875 to 1903, all the nineteen, without exception, took place when there was present on the sun a group of spots with projected area of over 1,000 millionths of the area of the whole disc; or when a group at one time very large had returned in a diminished form to the central meridian." In his second paper, which has been said with justice to establish "an entirely new conception of the solar action in producing our magnetic disturbances," Maunder showed that the cause of the magnetic disturbances is associated with limited areas on the solar surface. The magnetic action, he finds, does not radiate equally in all directions, but along definite and restricted lines. Thus, stream-lines from many spots may miss our earth altogether, and thus a great spot need not necessarily be accompanied by a magnetic storm. Maunder found an analogy to these hypothetical stream-lines in the long rays of the corona; and while not committing himself definitely, evidently inclined towards the view of Arrhenius that the streams consist of droplets formed by condensation in the solar atmosphere negatively charged and driven away by radiation-pressure. This hypothesis he spoke of as "entirely consistent with the appearance of the coronal photographs and with the conditions indicated by the magnetic storms."

Many of the problems presented by the sun seem at the present time as far from solution as ever. For instance, the cause of the equatorial acceleration, which has been aptly called a "legacy from chaos to cosmos," is yet unexplained; the reason of the solar cycle, too, is obscure, although probably its explanation is to be found in the fact of solar variability. That the sun is, to a very slight extent, a variable star seems to be definitely established by the researches of Abbott, whose measures of the solar constant indicate a real variability in radiation outside of, and independent of, the terrestrial atmosphere.

"The sun," Abbott concludes, "excepting perhaps in sun-spots, is wholly gaseous or vaporous. Except in sun-spots, the photosphere is too hot to contain solids or liquids. The density of the gases rapidly diminishes and their temperature rapidly falls from within outwards across the apparent boundary of the sun." Astronomers differ as to whether or not the temperature falls sufficiently to allow of condensation. Young maintained throughout his career that the solar photosphere consists of an envelope of clouds formed by the condensation of the solar vapours cooled by radiation into space. "The photospheric clouds are, of course, suspended in the surrounding gases and uncondensed vapours, just as clouds float in our own atmosphere." Abbott believes, on the contrary, that no condensation can take place at a temperature which exceeds 6,000° Absolute Centigrade. He accepts the view of the late Dr. Scheiner that the bright grains of the photosphere are the wave-crests of gaseous currents of different temperatures.

The impression made on the terrestrial observer by the sun is one of almost inconceivable magnitude and power. The great volume of the sun, over a million times that of the earth, its enormous mass, and the mighty forces which are at work in the solar globe, dwarf our planet and all our activities to insignificance. Yet modern astronomy has shown that the sun is a very insignificant member of the stellar system. The majority of the bright stars which illuminate our night skies are globes immeasurably superior to our "orb of day." Betelgeux, the size of which was measured in December last at Mount Wilson by interferometer methods, has a diameter of 273,000,000 miles, so that if we could conceive the gigantic star placed in the centre of our solar system, not only Mercury and Venus, but also our Earth and Mars would revolve within its circumference. Compared to these stellar giants, our sun belongs to quite an inferior order of celestial bodies; and our earth, which seems to us the end and aim of creation, turns out to be but a dwarf planet revolving round a dwarf star.

Past and Present

By O. G. S. Crawford, B.A., F.S.A.

ARCHÆOLOGY is the last subject to which one might think of attributing any direct practical value; yet it has, I submit, two very real claims thereto. It has a subjective value in producing a certain state of mind in its students; and it has an objective value because it helps to explain the origin of certain "subconscious" instincts which control our actions.

Let me take the subjective value first. Archæologists deal primarily with time in large stretches; they use man's primitive tools and weapons as tallies for measuring his progress, and they grow accustomed to the vista of long ages with scarcely perceptible change. Now, it is impossible to do this without being struck by the immense power of conservatism which throughout the past has kept the craftsman strictly to his ancestral model, and which has ordained that the new must disguise itself as the old if it is to survive. These are commonplaces, but they are necessary to my argument; for I wish to make it clear that archæology, by revealing these processes of tool-development, does so to expose their cumbrous and wasteful nature. Tools—in the widest possible sense of that word—are a means of attaining a certain end. Primitive man was fully conscious of the ends he had in view when he was making a stone axe or a sickle; but instead of conducting research experiments to determine the best kind of axe or sickle for his purpose, he slavishly followed the ancestral type. (What was good enough for his father was good enough for him, and so forth, a dictum reinforced, doubtless, by the elders of the tribe.) The survival of the fittest would, of course, operate in favour of the axes best suited, in shape or material, to achieve their purpose; but the natural law would operate infinitely slowly and in a haphazard manner. Primitive man is not extinct; his voice is heard whenever the results of competition in the open markets of the world are claimed to be better than those achieved by deliberate, organised scientific research. The "open market" policy was the rule of the Stone Age. Its underlying assumption was that men, though capable of selecting the best axe for their purpose, when it was made, were incapable of deliberately setting out to improve it by rational collective effort.[1] I am not blaming the men of the Stone Age for what was the necessary result of their primitive social condition. But the lesson of the last hundred years is that such collective effort, even when despised and rejected by "practical" men, is the *only* line of progress open to civilised communities.

There are only two types of men, conservatives and liberals, as Gilbert said. The conservative is ruled by precedent; he is seldom open to conviction and not always rational; the liberal, on the other hand, does not shy at a new suggestion merely because it is new and strange; he accepts or rejects it on its merits. During the earlier half of the first millennium before Christ, Britain was inhabited by conservatives who continued using bronze after iron was known and used by their Continental neighbours. (This was due to the vested interests of her copper and tin industry.) About the middle of this period some enterprising merchant of radical tendencies appeared in Wales. He knew about iron and could make tools of iron, but he was unable to dispose of them to his conservative customers. He therefore adopted an amusing stratagem. With great labour he made iron spears and sickles of exactly the same shape as the bronze ones which his customers were in the habit of buying, and to complete the deception he dipped them in molten bronze. He mixed up these counterfeits with genuine objects of solid bronze and took them all away with him on a journey. But his radical enterprise (to give it no worse a name) met with disaster, for he dropped the whole bagful of tricks into a lake. Had he not lost them, however, we should not have known of his enlightened efforts, nor should we be able to see them, as we now can, in a show-case at the National Museum of Wales.

Another subjective result of the study of archæology is the attitude it produces towards current events. One has to deal with the migration of peoples and with their evolution throughout long periods of time. One's outlook is, habitually and of necessity, a broad one in both time and space. More particularly one is constantly brought up against that strange, distressing phenomenon—the rise and fall of civilisation. (I assume that the archæologist is also interested in and familiar with the main outlines of historical development.) History and archæology alone can hope to explain this phenomenon; and when it has been explained, when its causes are discovered, we shall be half-way towards its cure. There, at any rate, is a fine practical problem to be faced! The present time is a most suitable one in which to make a start. Anyone who could find an explanation and a solution of our present troubles would, I am sure, earn the gratitude of Mr. Lloyd George, and might even hope for a good word from Lord Northcliffe, Mr. Horatio Bottomley, and other great leaders of thought. It is generally assumed that civilisation is declining

[1] "Research may be defined as the process of intentionally looking for something new; the value of some physical constant, a new material, or a method of performing some operation." F. H. Norton on "The Conduction of Research," *Scientific Monthly*, May 1921.

and that we are re-entering the Dark Ages. But those whose historical memory is capable of the effort are puzzled by the absence of the usual barbarian hordes waiting outside the gate to overwhelm us. Hitherto they have never failed to appear when the time was ripe for them—the Northerners in Crete, the Goths in Italy, and the Saxons and Danes in Western Europe. But now it seems that it is the stranger *within* our gates who is to set back the hands on the dial of progress. With unerring intuition our middle classes have divined the foe in what is conveniently summed up by the term Bolshevism. Nearly all the old familiar associations are present—the lower culture and the desire of loot, the destruction of idols and conversion by the sword. Only one is absent—the migration of large bands of people and the conquest and settlement of alien territory by people of the lower culture. But since nowadays the contending parties occupy the same geographical area in each instance, this migration is unnecessary, and the looting is also easier.

I have taken Bolshevism as a convenient example to show how the present can be interpreted in the light of the past. It is not possible to develop this theme here; but before passing on, I must refer to another, more general aspect of the same phenomenon. What has been the chief characteristic of these setbacks? Surely it was the making of a *fresh start* after each. After a blank period the writing begins to appear again upon the wall. To vary the metaphor, it is as if civilisation were unable to keep going continuously, but needed, like a living organism, long periods of sleep. It is as if men awoke after such sleep refreshed and full of vigour, remembering but dimly the days of long ago, and ordering their conduct without reference thereto. Conduct thus freed from the iron chains of precedent was easier and life at the dawn of history far simpler than nowadays, when we are crippled by the burden of a vividly remembered past. "Happy is the people without a history"; but to have had a past and to have forgotten it is, for a community, a still more blessed state. The accumulation of files and records complicates social life, and if continued long enough, may crush it by its dead weight. It is to society what memory is to the individual, or notes to the man of science.[1] Every research student knows that the chief difficulty in producing constructive work is to keep one's notes subordinated to one's purpose, to *defeat* them and fuse them into a living structure, to prevent them at all costs from terrorising and overwhelming one. When records, notes, or precedents outgrow the power of the individual and of society to deal with them thus summarily, the latter become sterile and rapidly degenerate into a mechanical rigidity. Reactions become automatic instead of intelligent; plasticity is lost and adaptation to environment ceases. When such a state of intellectual paralysis is achieved, no more is possible in that incarnation.

Let it not be supposed, however, because a period of "sleeping and forgetting" has hitherto been necessary, that it must always be necessary. It has been necessary in the past because things have been allowed to drift, because those at the helm have lost their bearings and surrendered to the blind forces of nature. Let me take from English history an example of what I mean by saying that it is sometimes a good thing for a society to forget its past. One of the most complicated transactions at the present day is the transfer of land from one owner to another. Why is this so? Because the method of transfer has persisted almost unchanged since the seventh century of this era, and this in spite of the fact that the community has caused to be prepared, for the express purpose of simplifying this procedure, an unrivalled set of large-scale plans of the whole country. But a small section of the community, with vested interests, has frustrated the intentions of the whole community, and persists in smothering under an unintelligible ritual of expensive jargon what should now be a perfectly straightforward business. It is difficult to see how these legal gentlemen are to be cured of their Anglo-Saxon habits without having an operation performed upon them by the rest of the community.

The history of our own country during the last millennium provides more than one example of the recurrent necessity for a "clean sweep." When the customary services of feudal times became intolerable, they were commuted for in money payment, which still survives as rent (only that nowadays one need not have Norman blood to be a landlord). But the extraordinarily involved allotment system of the common fields long outlived its original purpose, and was not finally swept out of existence until the Enclosure Acts of the eighteenth and early nineteenth centuries. (It still survives, I believe, in a few out-of-the-way places.) The Enclosure Acts may have borne hardly upon a few individuals, and upon the community as a whole in the loss of common lands; but the trend of modern expert opinion is to regard the injustice and loss as grossly exaggerated, and the national gain in efficient agricultural control as well worth the sacrifice.

The examples I have given show the value of an historical and archæological perspective in regarding questions of modern policy. Let me now deal with the objective value of this department of knowledge.

Every student of comparative anatomy knows that

[1] Samuel Butler called his note-books his "externalised" or "extra-corporeal" memory.

the human body is a museum of relics which have been acquired at various times during our evolution. All of them were once functional, but are now dormant, or awake only, like the appendix, to cause trouble. But it has been reserved for modern psychologists to discover—and promptly to obscure again by an unnecessary jargon—the equally obvious corollary that what is true of the body is true also of the mind and the nervous system. The sportsman inherits from the cave man not only his powers of physical endurance, but also his love of the chase. The capacity for co-operation is a legacy from necessities of prehistoric warfare; but so also is the herd-instinct with its blind cruelty to non-conforming individuals. We cannot eradicate during a few years of civilisation the habits that were formed during countless ages of savagery. Trite as this remark may seem, it has taken mankind a very long time to discover and elaborate its full implications. One of these is, that in order to eradicate, we must first learn what exactly it is we wish to eradicate. This can only come from a more detailed knowledge of our primitive ancestors and their environment. When we know how they passed their days and what their chief preoccupations were, we shall be able with greater certainty to infer their dominant instincts. From living primitive peoples we can find out a good deal by analogy, that is to say by the methods of comparative anthropology. But as Mr. Hocart pointed out (*Hibbert Journal*, 1919), there are pitfalls in this method. In a general sense, the comparative method, which is the method of Tylor, is, of course, valid; but we must be cautious in assuming in any given case that the culture in question represents a stage through which the human race as a whole—or any portion of it—has passed. It may be a degenerate stage, on the point of extinction. We once believed that Neanderthal man was on the direct line of our evolution, but now we know that he is not. (A more careful study of anthropoid embryology might have saved us from this error.)

To the student who is thoroughly inured to thinking in terms of millennia or centuries, this discovery of repressed or half-buried instincts by the psychologists comes as no surprise. One would like, however, to see the relative potency of these instincts more fully worked out, and some system of classification applied to them according to the length of their pedigree. In the more obvious cases (such as the sexual instinct) it is obvious that great power and a long pedigree are combined. If this is so, it should be true also that instincts with a short pedigree are less formidable, and more easy to subdue or divert into harmless channels until they exhaust or transform themselves. That such transformation is possible is now generally agreed. If, for example, archæological research proves, as it well may, that organised warfare is an institution of quite recent origin, we shall have a strong case against those who say "war has always been and always will be." Ultimately this line of argument is based always upon an assumed ineradicable instinct of pugnacity, developed by age-long immemorial strife between man and man. This assumption is quite unwarranted, and, in fact, unwarrantable in the light of modern research, which reveals abundant evidence of strife between men and animals, but none of strife between men and other men until quite recent times.

The long dark ages, when man was merely an animal, and the shorter twilight years when he was only half human, were the breeding-ground of the instincts we inherit but are only dimly conscious of. When these ages are more clearly revealed to us by the light of scientific research, we shall be better able to exorcise the evil spirits they have engendered; for here, at any rate, it is most surely true that knowledge is power.

Some Geometrical Canons of Architecture

By Arthur Bowes, A.M.I.C.E.

MUCH has been written on the use of geometrical figures as the basis of the design of ancient and mediæval buildings, and yet the subject may be said to be to a large extent undeveloped. Only a small portion of the ground has been investigated, and there is little doubt that further research, facilitated by the plentiful supply of detailed and measured plans now available, will discover methods, hitherto unsuspected, adopted by those who were responsible for the planning and designing of important buildings in the past ages. It is scarcely necessary to say that such methods are ignored in the present-day practice of architecture, when design is a matter of individual caprice and a freedom that acknowledges no subservience to any rules or canons of musty authorities.

In the comprehensive pages of the *Encyclopædia of Civil Engineering*, by Edward Cresey, and in Gwilt's *Encyclopædia of Architecture*, will be found lucid and well-illustrated explanation of the manner in which the proportions of ancient buildings were arrived at by the aggregation of units of geometrical form. The proportions of many of the Roman triumphal arches are there shown to be based on a circumscribing square, while the same figure is found as the key-note of later work in Italy and France. The equilateral triangle and the related hexapla, or six-pointed star, are also

shown to be the guiding principle in much Italian and late Norman work down to the end of the twelfth century, while the more subtle figure of the pentacle, or five-pointed star, is illustrated in ecclesiastical buildings at Rouen. An ancient cathedral or other important architectural work was in effect, then, a crystalline structure whose ultimate molecules had a definite shape, determined in each case by the root figure adopted in its design.

Nothing need be added to the full explanation given in the above-named works, though I may be permitted to refer to a more recent example as an indication of the method to be adopted in trying to find the controlling figure of the design. The Manchester Free Trade Hall was built so recently as 1856. In Baines's *History of Lancashire* the admirable great hall, noted for its acoustic properties, is described as being 134 feet long by 78 feet wide. Dividing one of these numbers by the other, we find that they are in the ratio of 1·72 to 1. Now, in the diamond-shaped figure formed by two equilateral triangles placed base to base, the foundation of the Vesica Piscis, the ratio of length to width is 1·732 to 1. In a chamber whose length is 134 feet, the width, if proportioned in this ratio, should be 77 feet 5 inches nearly, and the agreement with the published dimension is evidently so close as to justify the belief that the design was intentionally based on traditional methods. In the same chamber the height and width are in the ratio of 2 to 3, a proportion which will be referred to later.

It may be suggested here that a convenient way of detecting these and other root figures is to rule a sheet of tracing-paper into small triangles or squares as the case may be, and apply it to the published plans or elevations of the building under examination.

As to the reasons which led to the adoption of such figures, there is little doubt that in their first origin they were used from purely utilitarian motives. In *Ars Quatuor Coronatorum*, in 1906, I showed that, having regard to the want of instruments of precision, the equilateral triangle offered many practical advantages to the early builders in the setting-out of the work on the site as well as in the preparation of the preliminary plans. Great accuracy could be attained by its use on the ground, even when working with long wooden trammels or with stretched cords, and the setting-out of right angles was easily effected by constructing equilateral triangles on either side of a given line, base to base, and joining their apices. The intersecting arcs forming these two triangles constitute the correct form of the Vesica Piscis, around which many mystical associations have accumulated.

Instead of the architectural use of the above figures being founded on reverential and religious motives, consideration seems to indicate that their first adoption was a matter of practical utility, and that the association therewith of the various religious and philosophic trinities and recondite mystical symbolism was the result of a profound veneration for the wonderful properties of the geometrical figures, and, perhaps, a wish to preserve as a trade secret the knowledge of their use.

There is one root figure, a triangle possessing valuable properties of the nature referred to, that has so far escaped the notice of investigators, although when once pointed out it is impossible to avoid meeting its presence in multitudinous examples. I refer to the Pythagorean triangle, or triangle which has its sides in the proportion of 3, 4, 5. From the examples hereafter given it will be seen that this remarkable figure has formed a basis of design in architectural design work from the earliest days of Egyptian civilisation to a period of less than a hundred years ago. Its proportions can be traced in the measurements of ground plans and elevations of buildings, in the pitch of roofs, in the proportions of doors and windows, diamond-leaded panes, ventilating grilles, and other details of construction.

It may be remarked at this point that the proofs of the statement made below are matters of simple arithmetic, and to avoid any charge of dealing too sympathetically with figures in order to support a novel theory, I have in every case given the authorities from whom the measurements have been derived, so that the reader may satisfy himself of the value of the evidence offered.

The utility of this particular triangle for the purpose is easily demonstrated. It is the most suitable one for the setting-out of a right angle on a large scale—not the only one with sides in a definite ratio of whole numbers, but the one whose measures are easiest to carry in the memory and whose form best lends itself to accuracy of construction. The following triangles, amongst others, can also be used for the setting-out of a right angle:

5	12	13
7	24	25
8	15	17
16	63	65
20	21	29

but with the exception of the last the 3, 4, 5 ratio gives a better intersection of lines, and angles more fitted for practical setting-out. It is in regular use to-day in land surveying and in setting-out buildings. It also possesses other rather extraordinary properties which it is not necessary to detail here.

Two of the root triangles, having sides of 3, 4, and 5 units in length, when laid together in the manner shown in Fig. 1, form a rectangle measuring 4 by 3, and this proportion is traceable in many old buildings. Let us begin with St. Peter's at Rome. In the *Architectural Director*, a book on classic architecture by Mr. John

Billington (John Richardson, London, about 1820), it is stated that the principal nave of St. Peter's is 610 feet in length and the transverse is 457 feet. These

FIG.1.

FIG.2.

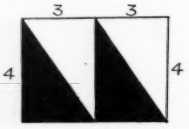

FIG.3

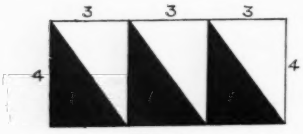

FIG. 4.

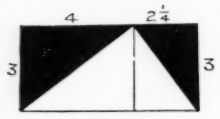

FIG. 5.

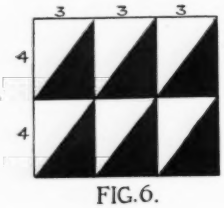

FIG.6.

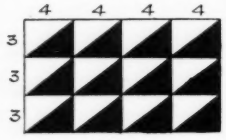

FIG. 7.

figures are within eight inches of absolute agreement with the ratio of 4 to 3.

In the grottoes of Benihassen, on the Nile, are two chambers whose measurements are given as length, 52 feet 5 inches ; breadth, 39 feet 4 inches. The floors of these chambers thus form rectangles in the ratio of 4 to 3, with a discrepancy of only one-third of an inch. (For measurements, see *Narrative of a Journey in Egypt*, by Thomas Legh, M.P. : Murray, 1816.)

The houses at Priene usually occupied a space of 80 feet by 60 feet (*The Planning of Hellenistic Cities*, Professor Percy Gardner ; *Transactions* of Town Planning Conference in London, 1910). At Silchester the remains of the old streets can be traced, and are laid out at right angles, with one large rectangle in the proportion of 4 to 3 for the central part of the town (Professor F. Haverfield, in above *Transactions*).

In English black-and-white buildings the prevalence of this root figure is very marked in the proportions of windows, timber-framing, roof gables, and sizes of rooms. Examples will be found in Hall-i'-th'-Woods, Bolton, illustrated in *Building World*, November 27, 1915 ; Bamfurlong Hall, in *Building World*, January 22, 1910 ; Old Clergy House, Alfriston, in *Building World*, November 25, 1911. Other examples might be added from French and Italian work.

By another combination of the root triangles, in the manner shown in Fig. 2, a rectangle in the proportion of 8 to 3 is obtained. In the Bottom Chamber in the Great Pyramid the end wall is said to measure 27 feet by 10 feet 6 inches, which is within 4½ inches of the above proportion. The measurements are taken from *Chambers's Encyclopædia*.

The main hall at Hampton Court is described in Cresey's *Civil Engineering* as measuring 106 feet by 40 feet. This is within 3 inches of the theoretical length calculated from the above ratio.

The arrangement shown in Fig. 3 gives a rectangle measuring 6 by 4, or 1½ to 1. It can be traced in Moorish work, but an interesting English example is the crypt of Ripon Cathedral, which, according to Bell's Cathedral Series, measures 11 feet 5 inches by 7 feet 7 inches. In this case the calculated width is within one-third of an inch of the recorded width.

In Fig. 4 is shown how the triangles are combined to form a rectangle measuring 9 by 4, a ratio which is sometimes found in ancient work. Thus, in the *Journey* of Mr. Thomas Legh, referred to above, the excavated temple at Guerfeh Hassan is said to measure 34 feet 6 inches by 15 feet 6 inches. The discrepancy here is 2 inches from the theoretical width.

An extremely interesting example of this proportion is afforded by the Parthenon at Athens. The measurements of this building, as given in *Harmsworth's Encyclopædia*, are 227 feet by 101 feet. By calculation the width is found to be within 1⅓ inch of the recorded width.

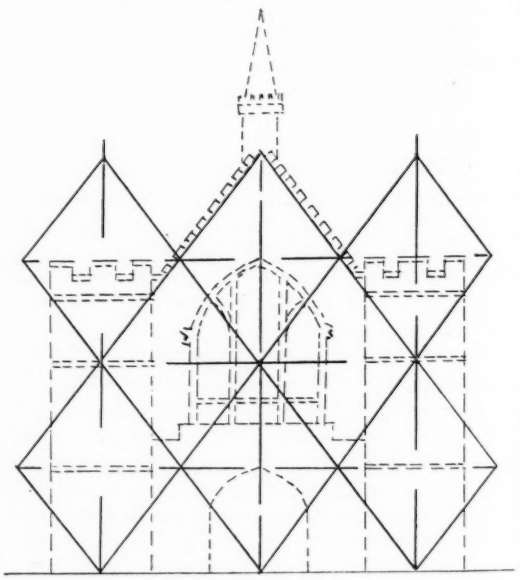
FIG.8.

A remarkable use of the root figure is shown in Fig. 5, where three right-angled triangles, each with sides in the ratio of 3, 4, and 5, are combined to

form a rectangle measuring $6\frac{1}{4}$ to 3, or 25 to 12. Now, the Temple of Zeus at Egina is said to measure 94 by 45 Attic feet, which is in the proportion of 25·068 to 12. The measurements in this case are taken from *An Apocalypse of Numbers*, by F. B. Bond (1915). The same ratios are said to be found in other Grecian and Ionian temples.

The next two combinations I have only been able to trace in ancient Egyptian work, but they are of especial interest as agreeing exactly with recorded measurements. Fig. 6, as will be seen, gives a rectangle of 9 by 8. In the old pyramid of Sakkara the base is said (*Wonderland of Egypt:* R.T.S., 1915) to measure 396 feet by 352 feet, which is exactly in the ratio of 9 to 8.

In Fig. 7 the rectangle obtained is in the ratio of 16 to 9, and this exactly accords with the measurements given of another excavated temple at Guerfeh Hassan, as recorded by Mr. T. Legh in the *Journey* before referred to.

As a last example, and as an illustration of the manner in which the 3, 4, 5 triangle entered into the design of the elevations of important buildings, apart from the arrangement of their ground plans, Fig. 8 represents the front elevation of Westminster Hall, the dimensions being taken from a fine steel plate in the *Encyclopædia Britannica*, 7th edition. On the elevation I have superimposed a network of diamonds, 4 units long and 3 units wide. Each diamond is, of course, made up of four 3, 4, 5 triangles. From the sketch it will be seen that practically all the proportions of the elevation are determined by the network of diamonds; the height and angle of the main gable, the centre lines of the side towers, the height of the towers, the apex of the entrance arch, and the position of the string courses being all determined by the various intersections of the lines forming the diamonds.

Many more examples might be added, but to those interested it will be an easy matter to compile a list of the ratios given and apply them as a touchstone to the measurements given in reliable authorities. The root figure, be it the 3, 4, 5 triangle, equilateral triangle, or its derivative figure the Vesica Piscis, can be often detected by a simple calculation. There is a peculiar fascination in thus unearthing the secret clues hidden, unsuspected as radium, for centuries. A new light is thrown on the principles which underlay so much of the art of the old creators of architectural beauty. The field of inquiry is a spacious one, and much remains yet to be revealed by patient investigation even in relation to some of the notable buildings that meet our eyes every day. Who is there, for example, of all the thousands who traverse the Thames Embankment, who could unveil the secret of the beautiful geometrical figure which shapes the proportions of Inigo Jones's stately Water Gate of York House?

Rising and Falling Prices—and a Remedy

By Arthur R. Burns, B.Sc. (Econ.)

II

THE simplest method employed in the calculation of the index number is to take a list of commodities, as far as possible unrelated to each other, and to compute from time to time the total cost of buying a given amount of each commodity. The total cost of all the commodities in the list is then expressed as a percentage of the cost at some agreed time, and this percentage is known as the index number and shows the rise and fall of general prices. Index numbers calculated in this way show that between 1789 and 1809 general prices doubled in this country and during the succeeding forty years they fell back to below level in 1789. Between 1849 and 1873 they rose 50 per cent., but between 1873 and 1896, in countries in which gold was the basis of the currency, prices fell again. By 1914 they had again risen by 35 per cent. In addition to these general movements, there have been more temporary fluctuations of the greatest importance—the economist Jevons found that for some time prices had shown a tendency to ebb and flow in a period of between ten and eleven years, and he endeavoured to connect this movement with the changes in the number of spots on the surface of the sun.

The effects of this ever-changing general level of prices, as apart from changes in the prices of individual commodities, are very serious from the point of view of both the business community and of the individual. When prices are tending to rise all those persons who hold stocks of commodities make a profit out of the increase in value of the stock between the time of purchase and of sale. Under such conditions it is easy to make profits, even for the men of small business ability, and the efficient man or firm can do well. The opportunity to make large profits induces traders and manufacturers to increase their efforts and also induces new men to compete for some of the gains (except in businesses where the high cost of the equipment required discourages them). Bankers are induced to assist by increasing loans, and the movement continues and increases in velocity, and a period of flourishing trade is experienced. If the higher prices were an indication of increased demand for goods, then the efforts to increase production would meet the demand and no ill need necessarily follow. Where, however, the high prices are merely due to monetary conditions which have caused a fall in the purchasing power of money (due to increased supply of money caused by an increase

in credit circulation made by bankers), when things come to be readjusted it will be found that there was, in fact, no great increased demand for goods, and that they cannot be sold. The adjustment used to come when the bankers began to realise that they were lending too great a proportion of the customers' balances in their hands. There was then a movement (initiated in practice by the Bank of England) to cut down the loans—by increasing the rate of interest payable on them. By definitely discouraging production and making it more expensive to trade on borrowed capital, a general endeavour to liquidate stocks and restrict business would be encouraged. The effort to liquidate stocks would tend to cause a fall in prices, and producers would hold their hands. While prices are falling the holding of stocks involves a loss, and in such times only the efficient can make profits and continue to trade and avoid bankruptcy.

When stocks have been consumed and demand again makes itself felt, business optimism will gradually develop and prices again tend to rise and the " cycle of trade " will commence and go through the same phases as before. Owing to the fact that it is possible, *by altering monetary conditions,* to cause prices to rise, and to make producers think that an increased demand for their product is showing itself, they are misled and at first increase their output and then later have to restrict it. Such continual alteration causes much unnecessary strain to the financial organisation—which sometimes gives way in a crisis. It also causes irregularity of employment. Workers are able to do well in the prosperous years, but suffer unemployment at times of depression. They are now demanding that some remedy shall be found for this unsatisfactory state of affairs.

The effects of rising and falling prices upon the individual are now familiar to all. Unless wages are increased at the same time and to the same extent as the purchasing power of money falls, the workers suffer. As there is always a considerable " lag " in this respect, much discontent is caused among workers. Those who engage in long contracts expressed in money are also at the mercy of any alterations in its purchasing power. If a man takes up a policy of assurance payable at the age when he estimates that he will be unable to work and for such an amount as will keep him, if prices remain at approximately the same level, then, if the purchasing power of money falls seriously—as it did between 1914 and 1920—he may find that, although he fulfilled his part of the contract and paid his premiums in money of a high purchasing power—yet, when the policy is paid, the amount is insufficient to keep him. The other side of the problem is seen when we consider that, if the purchasing power of money could be increased to its pre-war level, the present national debt would become a burden impossible to bear.

In the period before the war, as the banking system always operated to keep a fairly constant relation between the amount of credit created and the available gold, the general price level was harnessed (but not quite rigidly) to the value of gold. The knowledge of this fact enables us to explain many of the changes in the level of prices during the last century to which we have referred above. At times when fresh supplies of gold became available, the value of gold often fell (as would be expected) and prices rose as a result. When a new demand for gold for currency purposes was made —as when silver was demonetised by a number of countries—the value of gold rose and prices in gold-using countries fell.

During the war unprecedented alterations in the purchasing power of money have occurred, and all the evils of a variable standard of value have appeared to a degree which makes them unmistakable. The rise of prices has been accompanied by a great increase in the volume of the currency. The amount of gold in this country did not increase, but the ratio maintained before the war between the gold and the credit portion of the currency was very greatly decreased. The increased volume of the currency showed itself partly in the amount of paper money (currency notes) and partly in the increase in the amount of the loans by banks (especially the Bank of England). The effects of these changes have been very serious in both their social and their economic effects.

The real trouble lies in the fact that when gold was adopted as currency it was chosen on account of its suitability as a medium of exchange, as was mentioned at the beginning of this article. It has since, however, been required to act also as a standard of value. The rapidly increasing complications of the productive machine and the making of contracts, expressed in money, and covering a period of time, have rendered gold unsuitable to fulfil its function as a standard of value. The evils of the variations in prices consequent upon its continued use have been indicated above.

Professor Irving Fisher points out that we have now defined with the greatest possible minuteness our standards of weight and length and other similar units, but we have left the monetary standard in a most unsatisfactory state of " primitive crudity." The currency unit always represents the same quantity of gold, but it represents a varying quantity of every other commodity. As a measure of purchasing power it reflects all the changes affecting gold, but no other commodity. It is suggested that this should be remedied and that the unit of purchasing power should also be defined, and defined in relation, as far as it is easily possible, to all commodities that are purchased.

The scheme proposed by Professor Irving Fisher depends upon the index number to which we have

referred above. As this number indicates variations in the general level of prices, it can be used to correct these variations. When the index number shows that the monetary unit will purchase more than previously, the scheme provides that sufficient gold shall be taken out of the unit to cause its purchasing power to be the same as before. This would not, of course, be practicable if gold coins were in circulation, as was the case before the war. It is, accordingly, proposed that no gold coins be issued, but that the national stock of gold be kept in a central reserve and that gold certificates be issued in exchange for it and circulated as currency. These certificates would always be payable in gold on demand—in the same way as Bank of England Notes were payable in gold at a fixed rate (always 123·2744 grains of standard gold for one pound sterling). The new certificates would be redeemed at a rate published periodically—say every two months—by the Government. If, at the end of two months, the purchasing power of a pound had fallen (i.e. general prices had risen) by 1 per cent., the weight of gold given for a one-pound gold certificate might be increased 1 per cent. At the end of the next two months, if prices had continued to rise, the weight of gold to be given might be again increased. As soon as prices began to fall again the weight of gold to be taken as the equivalent of the pound would be decreased. Just as few people ever trouble to go to the Bank of England now for gold in exchange for Currency or Bank Notes, so at any time the alteration in the weight of gold that *could* be got would probably pass unnoticed by many individuals. While the monetary unit would always represent a varying amount of gold, it would much more nearly represent a constant value in commodities. As most of us wish to exchange money for goods and only the jeweller and a few others wish to exchange it for gold, the system would be much more reasonable from the point of view of the individual.

To the financial and commercial worlds the advantages would be equally great. At times when prices had been rising and the amount of gold to represent one pound had been increased, the store of gold held as national reserve would represent a less number of pounds than before, and if, as before the war, an attempt is made to preserve a constant ratio between the gold reserve and liabilities of bankers, a reduction of liabilities must take place. This would probably be effected by calling in some gold certificates, and thus banks, deprived of some of the legal tender paper, would call in some of their loans in order to balance their own positions. Thus, an increase in the published gold equivalent of the pound would result in the desired reduction in prices by decreasing the amount of currency available to do the money work. A decrease in the published gold equivalent of the pound would operate in exactly the opposite direction. In this way would be avoided most of the difficulties resulting from the " trade cycles " of the last century referred to above, for, in place of the jerky adjustments of the volume of the currency by bankers, the adjustment would be automatic and uninfluenced by the waves of optimism and of pessimism which used alternately to pass over the business world.

The stabilisation of the purchasing power of money would be of inestimable benefit in eliminating the present uncertainty introduced by our money into all relations between buyers and sellers, employers and workers, borrowers and lenders, insurers and insured, and all those classes entering into contracts expressed in terms of money. It should go far to eliminate misdirection of productive power through variations in money prices due to monetary influences. Any standard but an unvarying one involves uncertainty, unfairness, and hardship.

In conclusion, it is fair to say that one of the reasons which hinders the general adoption of the plan is the fact that the stabilisation aimed at is measured by the use of an index number. An index number for the whole world is, at present, an impossibility owing to there being no list of commodities which are purchased everywhere—demands of purchasers vary according to the place and conditions. It is also somewhat widely felt that even local index numbers are unreliable. There can be little doubt, however, that stability according to the best available local index number would be a very great step forward.

The other objection often put forward is that the alterations in the content of the monetary unit are left to the Government, and it is felt that opportunity for " adjustments " is thus given. If the index number were published, as is now the case, such " adjustments " would become obvious, for it would always be possible for the index number to be checked. The present system does not, however, prevent Government action from inflating the currency and depressing its purchasing power—for this was done during the war. During periods of war it is quite possible that the system might break down, but this cannot be lodged as a valid objection to its adoption in times of peace, for it *need* not break down in times of war.

The attempt to stabilise the purchasing power of money is an attempt to substitute exactness and certainty for random variation and uncertainty, and Professor Irving Fisher's scheme provides a reasonable method of doing this, and to him is due the credit for an invention which may prove to be of the most far-reaching importance to the world.

BOOKS

Stabilising the Dollar, by Irving Fisher. (Macmillan.)
The Purchasing Power of Money, by Irving Fisher. (Macmillan.)

Prehistoric "Cup-markings"

THE recent announcement in *The Times* of May 31 that Mr. L. M'Clellan Mann, the well-known archæologist, of Glasgow, has discovered a series of "cup-markings" on the surface of a rock at Green Island, Jersey, is of considerable interest in connection with the study of prehistoric man. Cup-markings are of fairly frequent occurrence in this country and on the Continent, and are found in many other parts of the world, including India, Australia, and North America. In form they are shallow depressions cut on rocks or erratic blocks, or on stones which have been adapted and worked by prehistoric man for a purpose such as the construction of a dolmen, or a monolithic monument. They vary in size from one to three inches or more in diameter, and in depth from a half to one and a half inches. The cup-markings found in Jersey are said to be identical with those found in this country, and are described as beautifully carved and perfectly circular. It has been stated erroneously that cup-markings have not hitherto been found in the Channel Islands; but two instances have been recorded from Guernsey, one on the prop-stone of a dolmen, the other on a "standing-stone."

A more complex form of cup-marking also occurs, in which the cup is surrounded by one or more shallow concentric circles. Not infrequently a radial groove runs from the cup or from one of the inner rings to the outer ring or even beyond. Two cups are sometimes found joined by a similar groove. The distribution of the cup-and-ring is somewhat peculiar: it occurs with some frequency in the northern counties of England, being, in fact, more often found than the simple cup, occasionally in the southern counties, in Scotland, and in Ireland; it also occurs in Sweden. Outside these areas, except for a few isolated instances, it does not occur elsewhere in Europe. Outside Europe it has been found in India, North America, Central America, and New Caledonia. A second peculiarity of the cup-and-ring is that in Great Britain it is usually associated with other forms of rock carvings, such as the wheel, the spiral, and sometimes the swastika, while in Sweden, in addition, it is often accompanied by representations of ships, both manned and empty.

Various conjectures have been made as to the object and meaning of these carvings. Their frequent occurrence on the topmost slab or capstone of a dolmen has suggested a sacrificial purpose, i.e. that they were intended to hold offerings or catch the blood of a victim; but the fact that they have been found on upright or slanting stones and rocks seems to preclude this idea. Their lack of arrangement would go to show that they were not intended to be decorative. It is impossible to say more at present than that they probably have a symbolic meaning, although their association with the wheel and swastika has been responsible for the suggestion that they are connected with sun-worship.

Both forms of cup-markings may be dated with a reasonable degree of probability. The frequent occurrence of cup-markings on dolmens and "standing-stones" indicates that they belong to the Late Neolithic or Early Bronze Age. This dating is borne out by the Jersey find. Green Island—which, it may be noted, is an island at high tide only, and has been separated from the mainland in comparatively recent times—is known from previous discoveries to have been the site of a neolithic burial-place. On the other hand, the form of the cup-and-ring suggests a later phase, while the symbols with which it is so frequently associated belong to the Bronze Age. A further indication is its occurrence on slabs used in connection with Bronze Age short cist burials, and on stones situated near such burials or in the neighbourhood of settlements of that date.

The problems of origin and distribution present many points of interest, of which space does not permit the discussion here. In the case of Jersey and Guernsey, it would be natural to look to Brittany as the source. In prehistoric times, and particularly in the Neolithic and Early Bronze Ages, there was close and frequent intercourse between the Channel Islands and Brittany. Sculptures of various forms are of frequent occurrence on the megalithic monuments of the latter area, and among them a number of examples of cup-markings occur. It has been suggested that the cult of a goddess, for which there is evidence in the sculptures on the monuments of Brittany and Guernsey, is to be derived from the Ægean. It is, perhaps, significant that cup-markings have been found in the south of France: at Luchon, in the Pyrenees; in the Department of Lozère, and in the Valley of the Rhone. They also occur in Portugal. These instances all carry back the cup-marking along the line of the dolmen-builders in their movement from the Mediterranean around the coast of the Iberian Peninsula and France to Brittany. On the other hand, it must not be forgotten that cup-markings are of frequent occurrence on the erratic blocks of Switzerland. Further, the late Mr. George Coffey, in tracing the spiral, with which the cup-and-ring mark is so frequently associated, to the Mediterranean, held that it reached Ireland from Scandinavia.

E. N. FALLAIZE.

Correspondence

To the Editor of DISCOVERY.

SIR,

Will you kindly allow me to make one or two remarks with regard to Mr. J. S. Huxley's review of my book on *Symbiosis, a Socio-Physiological Study of Evolution*, which appeared in the June issue of your esteemed journal?

Mr. Huxley, I am glad to say, has something favourable to say at least about my exposition of Symbiosis as a factor of progressive evolution. But behind the morphological study of Symbiosis (with which many are content) there lies that of the "payability" of Symbiosis. And this very important subject quite inevitably opens up those economic and pathological considerations which loom so largely in my book. On truly co-operative methods, Symbiosis pays well. On any lapse to methods of mutual plunder it pays less well, and the symbiotic relation, and all that it entails, may come to an end ignominiously.

For very good reasons, I hold that the same sequence obtains on the grand scale of Nature; and in this way I explain degeneration and extinction. Mr. Huxley admits that the principle involved in Symbiosis, namely partnership, is the cause of much that is good in evolution. But, like many other biologists, he cannot yet bring himself to realise that, inversely, the opposite principle, namely predacity, is responsible for much that is evil.

I will not ask him to accept my conclusion in a hurry, nor as the necessary corollary of the proposition to which he shows greater readiness to subscribe. I hope in due time to publish such facts as to leave no doubts in the matter. All I would urge for the moment is this, that evolutionary pathology is still rather backward, and that the very important matter of "correlations" has been sadly neglected. Perhaps one should not attempt to do too much in a hurry. But with "correlations" duly focused, I have no doubt Mr. Huxley, and with him a number of broad-minded biologists, will see eye to eye with me much further than they do to-day.

Yours faithfully,
H. REINHEIMER.

THE FAIRY PHOTOGRAPHS

To the Editor of DISCOVERY

SIR,

I notice in the current number of DISCOVERY that the fairy photographs are clever fakes. I should be very glad to know your reasons for this opinion. Mr. Gardner and I have examined this question, know the people concerned and their life history and capabilities, have had the second set of results upon plates marked by ourselves, and have had the results enlarged to their full capacity and examined by several of the greatest experts in England, who could find no sign of any fake.

On the other side is the irresponsible opinion of a young man who has never even taken the trouble to examine the negatives, although it was stated in the article that Mr. Gardner held them for reference.

You are probably aware that the *Westminster Gazette* sent up a very critical Commissioner, who shook our story in no way, and declared that he had no doubt as to the bona-fides of the family concerned. He brought out the fresh fact that it was the first time the girl had ever been allowed to use her father's kodak.

In the face of all this we have a right to ask you what possible precaution we have neglected, and what right you have to brand us as foolish dupes, unless you have some evidence to upset our conclusions.

Yours faithfully,
A. CONAN DOYLE.

[The existence of fairies is something very strange and very new. No one should shout down or think any the less of a man who puts forth a plea for their existence, although to many it appears nonsensical. It may be true or partly true, and even if it be not true an investigation may lead to something important or helpful. Science is not so overburdened with ideas that it can afford to dispense with any. On the other hand, we have the right to adopt a doubting-Thomas attitude towards the alleged new fact. If we can be convinced, as Thomas was, well and good; if not, we may either suspend judgment, or point out where we think the putter-forth of the view has, as we think, erred, or been deceived.

The burden of Mr. Vincent Patrick's remarks which I quoted in the Editorial Notes was that photographic evidence (*a*) may be untrustworthy even when the photographer is perfectly sincere and trustworthy, and (*b*) may easily be faked so that people may be deceived. Because of this, photographic evidence must be secondary. It may confirm; I do not think it can convince. The evidence that is wanted is the assertion by qualified and trustworthy persons (such as the members of a learned society), in normal health, that they have seen the fairies with their own eyes. If this assertion can be made, we need worry neither about photographic evidence nor about the good faith of those who have been concerned in the production or the critical examination of the photographs. Until it can be made, critics have a right, as a matter of interest, to indicate possible ways in which a camera may appear to record things which have not been seen by the eyes.—Editor.]

Reviews of Books

Bibliotheca Chemico-Mathematica. A Catalogue of Works in Many Tongues on Exact and Applied Science. Two Volumes. (Henry Sotheran & Co., 63*s*.)

It may be news to some that there is a demand for old books on science. Not only is the demand a real one, it is one that grows from year to year. I do not think that scientists or students of the history of science will

ever take the same interest in old books in their subject as do the enthusiasts who collect first and early editions of works of literature, for the scientist is necessarily too much concerned with the present to care very much about the past. A study of the history of his science must be left to leisure hours, and if there is awakened in him an archæological interest in his subject, such as is evinced by a desire to collect old books about it, it is an interest which is quite separate from, and not part of, his interest in the facts of science.

That a study of old books may be not merely interesting and entertaining but stimulating and helpful also may be very clearly proved by a perusal of this catalogue. So wide an interest does it give a reader in the long and distinguished past of the physical sciences that I have no hesitation in saying it should be in the hands of every lover of the sciences fortunate enough to have the means of possessing it. These two volumes are a bookseller's catalogue. Booksellers' catalogues have often been very beautiful and interesting productions. These books are a very beautiful and interesting production. They are a sale catalogue arranged by authors' names of about seventeen thousand books in Mathematics, Astronomy, Physics, Chemistry, and one or two other subjects. Most of these are old books, but there is also a supplement containing the names of new and up-to-date books. Against each book is given the date of publication and its present price. A description of the book, and in many cases pithy and pawky remarks concerning it, are appended to its name. Many of these notes deal with the historical or archæological interest of the book.

If these volumes were only a catalogue of the usual type, they would be of great interest, but the illustrations make them still more valuable. They are facsimile reproductions of letterpress, title-pages, wood-cuts and diagrams, portraits and photographs, taken from the rarer or more important works. These illustrations, we are told, have been prepared by a photographic process. Their production is singularly beautiful. There are portraits of Newton; Huygens, famous in optics; John Napier of Merchiston, a pioneer of logarithms; Torricelli; Dr. Thomas Young, the discoverer of interference; the Hon. Robert Boyle (he crops up in every historical scientific book); Faraday, Galileo, and Laplace. A page of the first printed edition of Euclid's *Elements* (1482) is reproduced; four illustrations of Daguerre's photographic apparatus from his book (1839); Hevelin's map of the moon (1647); the title-page of an excessively rare work of Kepler, giving the first two of his "three laws" (1609); a drawing of the earliest practical electric telegraph apparatus (invented by Sir Francis Ronalds, 1816); one of Ovenden's "new machine to go without horses," an early forerunner of the bicycle (1774); a page of Huygen's treatise on light, in which the author propounded his theory of "elementary waves" which enabled him to explain the reflexion and refraction of light on the basis of the undulatory theory; the title-page of the first issue of the first edition of one of the greatest works on exact science ever published, Newton's *Principia*.

Let us now look at the description and prices of some of the books themselves. For the best edition of the *Principia* eighteen guineas is asked. It is interesting to note that the cost of the printing of this edition was borne by Halley, the comet man. He edited it also and saw it through the press. Samuel Pepys, the diarist, then, if you please, President of the Royal Society, gave the book the Society's *imprimatur*. The first edition became rare almost immediately after publication, for a copy was procurable, we are told, in 1691 only with great difficulty.

Another book of about the same period, not of quite the same scientific importance, but quainter, was Sir Kenelm Digby's *Of Bodies and of Man's Soul. To Discover the Immortality of Reasonable Souls with Two Discourses of the Powder of Sympathy and of the Vegetation of Plants.*

Digby was an interesting type who first described his "powder of sympathy" in a lecture which was supposed to have been delivered at Montpellier in 1658. The principle on which this "powder" worked was akin to the well-known method of catching a bird by applying salt to its tail. The powder healed a wound not, as you might imagine, by its being applied thereto, but by being kept away from it. The procedure was as follows: A bandage which had encircled the wound was removed from it and immersed in the powder, and *kept there till the wound was healed.* Quite clearly, Digby was an impostor, yet he seemed to have impressed James I and others with its efficiency.

Mr. Sotheran has also a fine copy of the excessively rare original edition of Copernicus' work, *On the Revolution of the Heavenly Bodies.* This work, which, to use the optimistic phrase of the modern publisher, was certainly "epoch-making," was completed in 1530, but not published till the close of the author's life. In 1542 the poor fellow was seized with apoplexy, and next year, just before he died, the first printed copy of his book was brought to him. He looked at it, touched it, and later expired.

Many quaint works are described in this catalogue. There were always plenty of authors, it seems, to rush into print to demonstrate the accomplishments of a successful perpetual-motion device, or to prove that the earth is as flat as your hat. As early as 1532, Robert Valturio published in Paris the details of a cannon for hurling projectiles "round the corner"! This is evidently a lost art! Ovenden's description of the machine which travelled without horses has many quaint touches. This machine was "capable of travelling, with ease, six miles in an hour; and by a particular exertion of the footman, might travel nine or ten miles an hour on a good road, and even would go up a considerable hill." The illustration shows that the master sat in front, while the "footman" (appropriate name!) perspired behind.

This catalogue, indeed, is a joy. Rich in biography of great scientists, it touches lightly and even gaily on the eccentricities of the past, yet rightly calls attention to the really important books and the theories or discoveries which they contain. It is scrupulously well edited, and the illustrations are a perfect marvel of delight.

A. S. R.